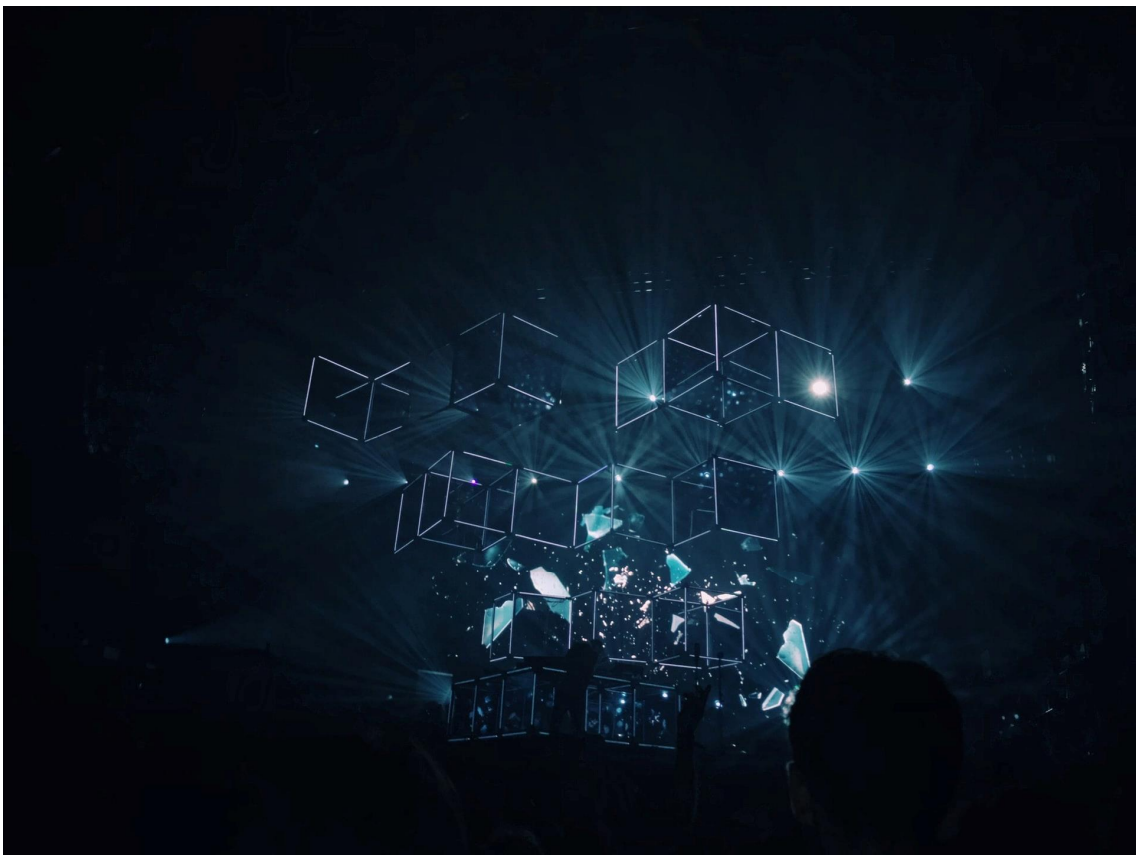
InDEA 2.0



InDEA 2.0

India Digital Ecosystem Architecture 2.0

सत्यमेव जयते

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Ministry of Electronics & IT

Government of India

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PREFACE

From systems to ecosystems. That is the new order. Blurring of organizational and system boundaries is happening continuously. Agile is the new watchword – agile governance, agile development, and agile architecture! We see the beginning of the era of digital ecosystems, which are constellations of several large, autonomous systems - interdependent and interoperable, and which can collectively deliver a swathe of innovative services at population scale.

India Enterprise Architecture (IndEA) was designed in 2017 with a view to enable alignment of the IT developments with the business vision of government organizations. It provides a set of architecture reference models aimed at a holistic and integrated approach to e-Governance. As a sequel to it, Agile IndEA Framework was developed in 2019 to make the architecture development to be taken up in shorter cycles. The MeitY white paper on National Open Digital Ecosystems or NODEs published in 2020 is a set of principles, which emphasizes that governance frameworks and community-engagement are essential components of a digital ecosystem. It defines NODEs as "*open and secure delivery platforms, anchored by transparent governance mechanisms, which enable a community of partners to unlock innovative solutions, to transform societal outcomes.*"

Reviewing IndEA framework was expedient considering the paradigm shift proposed by NODE, coupled with the emerging demand in several Ministries and State Governments for a holistic but simple architectural approach. InDEA 2.0 seeks to address this felt need.

InDEA 2.0 harmonizes and builds upon the architectural frameworks developed during the last few years. While codifying their principles, it provides a pragmatic approach to realize the concept of open digital ecosystems in an integrated and collaborative manner. It recommends a value-driven approach, a focus on capability building and above all, a preference to 'enabling' rather than 'building'. It is an evolving and dynamic framework with continuous improvement as its *mantra*.

An architectural framework cannot be prescriptive or overly descriptive. InDEA 2.0, therefore, leaves enough degrees of freedom for those taking up transformational digital initiatives at the national or state levels to build innovative, agile, and efficient architectures and solutions that best suit their specific needs.

Knowledge without power is ineffective. Power without knowledge is wasteful. It is the right combination of knowledge and power that can create innovative, holistic, and sustainable solutions and outcomes. It is fervently hoped that the InDEA 2.0 framework enables establishing such a right balance in all the ongoing architectural initiatives and accelerates the realization of the vision of Digital India.

J Satyanarayana — Chairman

Ajay P Sawhney — Co-chairman

EXECUTIVE SUMMARY

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Executive Summary

What is InDEA 2.0 ?

India Digital Ecosystem Architecture 2.0 or InDEA 2.0 is a framework that enables Governments and private sector enterprises to design IT architectures that can span beyond their organizational boundaries and enable delivery of holistic and integrated services to the customers. While InDEA 2.0 builds upon the principles and models recommended in India Enterprise Architecture (IndEA 1.0 - 2018), it adopts a radically different approach to architecture development. It addresses the architectural needs of an *ecosystem* rather than of an *enterprise* which was the focus of its predecessor.

InDEA 2.0 is a framework that promotes the evolution of digital ecosystems. It consists of a set of principles and architectural patterns that inform, guide, and enable the development of large digital systems, with a focus on the public sector. The following statements define the characteristics of InDEA:

- InDEA is applicable more to ***ecosystems*** than to ***systems***.
- InDEA offers a set of ***architectural patterns*** but not an ***architecture***.
- InDEA prefers ***enabling*** to ***building***.
- InDEA is ***agile and evolving***, and not **rigid and inflexible**.
- InDEA is ***unifying*** and does not force **uniformity**.

Why InDEA 2.0 ?

The boundaries between functions, jurisdictions and public-private organizations are getting blurred due to increasing interdependencies and the need for citizen-centric approaches to designing digital services, as opposed to organization-centric approaches. The need to provide end-to-end services, adopting the methods of digital transformation, agile development methods, disruptive business models, and above all, the as-yet unfathomable opportunities offered by the emerging technologies like AI, ML, IoT and DLT are strong forces pushing the limits towards the evolution of digital ecosystems.

The core value proposition of InDEA 2.0 to the Governments is in terms of a more rational planning of IT investments, cost savings due to reusable and interoperable systems, and better architectures designed faster. To the citizens, it means a more holistic and seamless experience across organizations. And to the industry, it holds out immense promise of innovation.

The InDEA 2.0 framework is useful to the policy makers in the government, and architects and system designers in the public and private sector.

InDEA 2.0 Principles

A large national framework should be based on a set of generic principles, but not prescriptions. InDEA 2.0 propounds a set of 27 principles in 5 categories, namely, ecosystem, architecture, business, technology, and architecture governance. The 'principle of these principles' relates to enabling rather than building. Federated architecture, openness in designs, modularity and interoperability are core among the set. Security- and privacy-by-design, and agile governance are among the other key principles.

Upholding the primacy of the principles and adoption by all organizations would produce a multiplier effect and thereby pave the way to realizing the goals of InDEA 2.0.

Building Blocks, the essence of InDEA 2.0

In line with the basic philosophy of enabling, InDEA 2.0 envisages development of architecture by the ecosystem players by using a set of Building Blocks. A building block is a package of business or technical functionality, which is reusable, stable, and scalable. Every building block has a business owner and a technology owner. A building block is interoperable with other building blocks through well-defined and stable APIs. Building blocks are like Lego blocks using which we can build different structures.

InDEA 2.0 defines 3 types of building blocks, namely, **core, common and reference** building blocks. Core building blocks play a pivotal and central role and occupy an extremely important position in the architecture. Because of their extremely useful functionality they are accessed by most of the other building blocks. Common building blocks are reusable across multiple organizations. Reference building blocks are most often functional and technical specifications but not working applications. The actual architecture of the digital ecosystem of any sector, ministry or State can be derived through an appropriate combination of the core, common and reference building blocks identified by InDEA 2.0 and supplemented by other context-specific applications.

The InDEA 2.0 report recommends a highly selective approach to the design and development of the building blocks. **Only the core building blocks are proposed to be designed, developed, and managed centrally by the central or state governments**. From a governance perspective, the government plays an enabling role in respect of the remaining building blocks.

InDEA 2.0 Master Plan and Architecture Patterns

InDEA 2.0 Master Plan is like the master plan of a city. InDEA 2.0 Architecture Patterns are like the type designs of housing colonies and public infrastructure in a city. The master plan plays a triple role. It hosts the core and common building blocks. It acts as a repository of all architectural artefacts of InDEA 2.0. Above all, it acts as the model for development of ecosystem architectures, through its 3-layer federated structure. In view of its pivotal importance, the master plan is reproduced below.

The pivotal role of the master plan arises out of the core building blocks, the most important of which are the registries and directories which are sector-agnostic and pan-India. The architectural portal also plays a very important role in making available the building blocks, artefacts, standards, and specifications in a dynamically up-to-date fashion.

The master plan is constituted by a set of 45 building blocks organized into 10 groups or 'zones' of the master plan. 5 of them are core, 12 are common and 11 are reference building blocks. The rest are building blocks at the domain or state level.

InDEA 2.0 *makes architecting simple* by adopting the 'pattern approach'. InDEA 2.0 comprises of three architectural patterns suited to different administrative environments, and the Master Plan binds them together.

The **Domain Architecture Pattern** is most suitable to be adopted by the line ministries of GOI that deal with concurrent subjects or state subjects that have substantial funding and/ or involvement of GoI. The **State Architecture Pattern**, as the name indicates, is to be adopted by the States and UTs. While this pattern encompasses all the subjects administered by the State governments, the States can implement it in a phased manner depending upon their own priorities and resources. The **InDEA Lite Architecture Pattern** is recommended for adoption by small departments which intend to produce quick wins 'on their own'.

A significant amount of systematic effort is required for any ministry, department, or State Government in converting the patterns into implementable solution architectures. This requires specialized capacities and competencies.

Federated Digital Identities

Digital Identity is fundamental to enabling the citizen to answer the first question asked in any interaction with public or private organization – 'who I am'. While Aadhaar seems to have answered this question at population scale in respect of all publicly-funded schemes, the ministries and States are required to create several identities for the same citizen acting in different capacities like student, teacher, farmer, land owner, entrepreneur, customer of a bank, driver, owner of a vehicle, pensioner and so on. InDEA 2.0 proposes a model of Federated Digital Identities that seeks to optimize the number of digital identities that a citizen needs to have. The model empowers the citizen by putting her in control of these identities and providing her the option of choosing which one to use for what purpose. It gives the agency to the citizen and protects privacy-by-design. The same logic holds for entities. And the model is generic enough to establish identity ecosystem for entities as well.

Emerging trends in Open Digital Architecture

InDEA 2.0 is about empowering the individuals and entities. While the ecosystem of digital identities forms the foundational layer, at least two more layers are required to ensure that the ecosystem functions and delivers. These are the 'assets layer' and 'transactions/interactions layer'. Several initiatives have been successfully implemented to demonstrate the power of one or more constituents of these 3 layers – identities, assets and transactions. InDEA 2.0 introduces these emerging trends in the form of verifiable credentials, open networks and protocols. The list consists of Aadhaar, UPI, GSTN, Account Aggregator and the upcoming frameworks of UHI, NDEAR and ONDC.

InDEA 2.0 Implementation Framework

InDEA 2.0 is an ambitious framework in so far as digital ecosystems are themselves complex to visualize. For this very reason, Governments are well advised not to try to implement it by themselves. They should *enable* the ecosystem players to implement different parts. The

enablers are of two types (i) **policy enablers** like PPP Framework, special procurement policy (e.g outcome-based procurement), data sharing policies and rules of engagement of ecosystem players (ii) **technology enablers** like, sandbox(es) and data exchange(s).

The key steps in implementation include developing a **vision** for the domain/ State/ Organization, developing a Digital Ecosystem Blueprint consultatively and adopting agile methods for developing architecture and applications. Ultimately, an architectural effort inspired by InDEA 2.0 will succeed in producing the desired impact if the sponsor can 'reimagine' the sector/ domain and conceptualize **at least one gamechanger** which has the potential to make a huge difference. The role of the leadership at political, administrative and technology levels is critical to create such impact.

From capacity building to competency building

InDEA 2.0 requires the coordinated efforts of multiple stakeholders over the medium and long term to produce widespread impact and achieve the goals of interoperability, citizen-centricity, and innovation. Governments need to go an extra mile in creating in building not capacities but competencies. While ***capacity*** indicates the ***potential*** to perform, ***competency*** indicates the existence of empowered multi-disciplinary teams that have the fitness to ***execute*** large programs. Braodly, it is the difference between 'thinking' and 'doing'. These competencies are required to be built in both the public and private sectors at the policy, administrative and technology layers of organizational hierarchies. A blended model containing F2F and online programs with appropriate curriculum for various programs has been recommended in the report.

To conclude, InDEA 2.0 is one of the critical enablers in the evolution of a digital economy. **India will do well to adopt InDEA!**

Messages

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1.1. Context of InDEA 2.0

The only thing constant in Information Technology is the radical and disruptive change that occurs regularly. The domain is continuously impacted by new technologies, new architectures, new delivery models and above all, a new user experience. We are currently at the peak of the transition of systems from *electronic* to *digital*. Among other such things we are witnessing the beginning of a big change in the concept and practice of Enterprise Architecture, which held its ground for about two decades. Ideas like agile manifesto, DevOps and Open Digital Ecosystems are disrupting the principles and practice of Enterprise Architecture.

India Enterprise Architecture or IndEA was notified as a standard framework of enterprise architecture by the Ministry of Electronics and IT (MeitY), Government of India in 2018. IndEA 1.0 is a set of business and architectural principles, and 8 reference models that encapsulate these principles. The uptake of IndEA had not been significant in two years, despite the efforts to create awareness among the Ministries and the States. MeitY realized the need to modify, enhance and simplify IndEA framework for some other reasons like being resource-intensive, and prescriptive. The strongest reason however is, the emergence of new concepts alluded to in the previous paragraph.

MeitY constituted a Steering Committee to design an architectural framework for digital government that is agile, user-friendly, and lightweight. The constitution of the Steering Committee is in **Annexure IA**. The Committee met 8 times during the period Aug 2020 to January 2022 and designed a new framework termed as India Digital Ecosystem Architecture or InDEA. The Committee constituted a Working Group to examine the issues in depth. The constitution of the Working Group is given in **Annexure 1B**. The principles and structure of InDEA framework are presented in this report.

1.2. WHAT is InDEA ?

InDEA is a framework that promotes the evolution of digital ecosystems. It consists of a set of principles and architectural patterns that inform, guide, and enable the development of large digital systems, with a focus on public sector. The following statements define the characteristics of InDEA:

- InDEA is applicable more to ***ecosystems*** than to ***systems***.
- InDEA offers a set of ***architectural patterns*** but not an ***architecture***.
- InDEA prefers ***enabling*** to ***building***.
- InDEA is ***agile and evolving***, and not **rigid and inflexible**.
- InDEA is ***unifying*** and does not force **uniformity**.

Since the central theme of InDEA is digital ecosystem, it is necessary to explain the term and to delineate its boundaries in the current context to set the expectations right.

A digital ecosystem is a distributed, adaptive, and open socio-technical system with properties of self-organization, scalability, and sustainability.

A digital ecosystem can be large and nebulous. In the context of InDEA, the digital ecosystem is visualized to extend to various sectors of the economy, with substantial emphasis on the services provided by the public sector, while providing enabling environment for the private sector and innovation. In other words, the primary goals of InDEA relate to G2C, G2B and G2G space and the secondary goals include playing a facilitatory role in the B2C and B2B space. In sum, InDEA is substantially about digital government.

1.3. WHY InDEA 2.0?

Before addressing the question 'Why InDEA 2.0?', it is necessary to address the preceding question 'Why digital ecosystem approach?'. The need for thinking beyond digital systems and paying attention to digital ecosystems at this stage of evolution is arising now due to the following reasons:

a. **Blurring boundaries:** The boundaries between functions, jurisdictions, public-private organizations are getting blurred due to increasing interdependencies and the need for citizen-centric approaches to designing digital services.
b. **End-to-end services:** Citizens are increasingly expecting fulfilment of their needs on an integrated and end-to-end basis. This calls for seamless and automated collaboration between multiple organizations and their systems.
c. **Digital Transformation:** The transition from e-Governance to digital governance calls for raising above the traditional systems approach.
d. **Leveraging innovation:** The potential of explosive and disruptive innovations happening via emerging technologies like AI/ML, IoT, DLT, AR/VR can be leveraged only if cross-cutting and pervasive digital environment is established.
e. **Disruptive Business Models:** An ecosystem approach provides the flexibility and complementarity required for the growth of disruptive business models that can enhance efficiency and effectiveness at a lower cost.

InDEA 2.0 Value Proposition

While the basic justification for InDEA 2.0 derives from the foregoing discussion on digital ecosystem approach, the case for InDEA 2.0 stands on its own feet due to the specific value it proposes to various stakeholder groups as described in the **Table 1.1.**

Stakeholder Group	Specific value proposition	Basis of value
Citizens, businesses, end users	• Integrated services	• Interoperability across ecosystem • SSO
	• Innovative, value-added services	• Open standards, specifications, and Open APIs
Government	• More effective planning	• Holistic view of ecosystem • Data-driven decision making
	• Cost savings	• Avoidance of duplicative development efforts • Optimal utilization of IT assets • Minimization of data collection and management costs ('once only' principle)

	• Better architectures designed faster	• Adoption of the principles and patterns of InDEA 2.0
Industry	• More active participation in digital government initiatives	• Clarity of goals • Outcome-based procurements
	• Reduced costs in providing services to public sector	• Open Standards and specifications
Innovators/ startups	• Ease-of-Doing-Innovation (EoDI)	• Innovation policy • Ecosystem sandboxes
	• Transparency and cost-effectiveness in data discovery and exchange with public and private sectors	• Ease of access to test, validation, and production data of the public sector through open data platforms • Data Exchanges

Table 1.1: Value proposition of InDEA 2.0

Project level value proposition: InDEA 2.0 is not a digital transformation project by itself. It informs, guides, and inspires many digital transformation projects in the public and private sectors to realize the value propositions stated above. Each such initiative - ongoing or future - must define the need for and purpose of adopting InDEA 2.0 in non-technology terms to enable the governance authorities to take appropriate investment decisions, and / or to modify goals suitably. Each project should aim to define the significant problems or issues of the sector that it intends to solve and establish how InDEA 2.0 could be one of the key instruments in such an endeavor. Collectively such initiatives in each sector should demonstrate *unity in diversity* by conformance to a shared vision.

1.4. Intended Audience

InDEA 2.0 framework defined in this report is principally meant to benefit the following categories of stakeholders.

- **Policy makers**: can benefit from aligning the IT investments in ways that are outcome-oriented, provide benefits across the ecosystem, and are open and transparent.
- **Architects**: can design business and technology architectures faster and in a more holistic way by adopting the principles and patterns recommended here.
- **Industry**: can contribute to the growth of InDEA 2.0 by co-creating processes for sharing data, designing protocols and defining APIs.

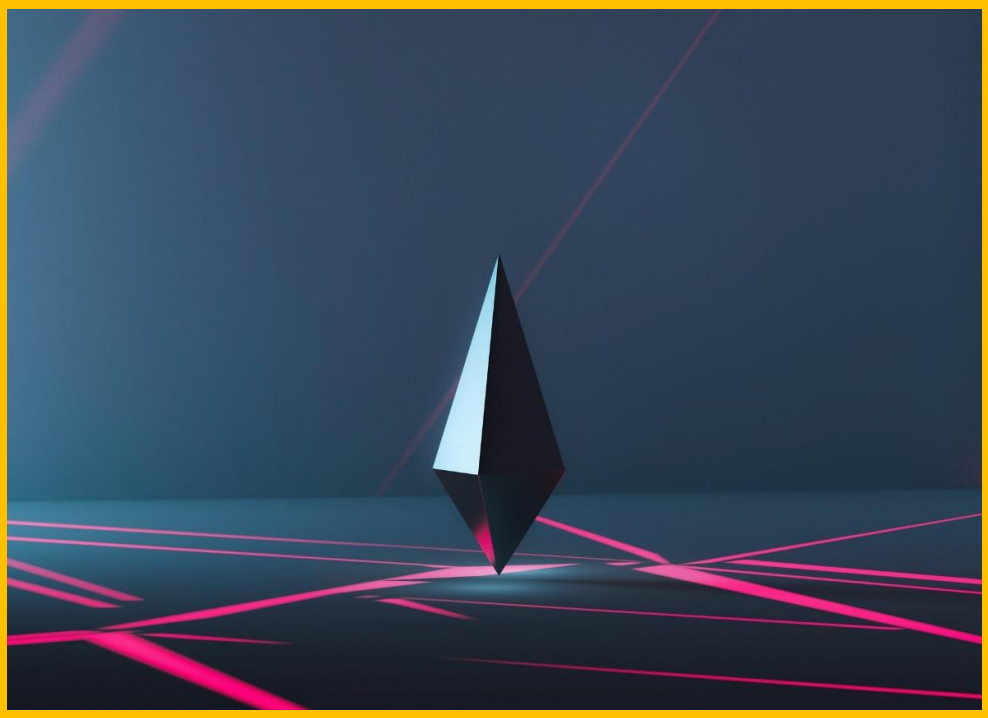
InDEA 2.0 is a concept that applies across several ecosystems. It is not feasible nor appropriate for the public sector to develop all the building blocks. It can happen only through the active involvement of the community. The Central and State Governments can do well by promoting 'InDEA 2.0 Community' through an initiative that can be called **JoinUp InDEA**. The InDEA 2.0 community can crowdsource, curate and publish the specifications of the various building blocks of InDEA 2.0, and the interfaces.

1.5. Structure of InDEA 2.0

InDEA 2.0 is a set of principles and architecture patterns, along with guidelines for its adoption /implementation and capacity building. Chapter 2 deals with the principles on

which InDEA 2.0 is founded. Chapter 3 defines the InDEA architecture patterns. Chapter 4 gives an overview of the federated digital identities as an approach to overcome the problem of proliferation of identities. Chapter 5 touches upon the emerging trends in digital ecosystem architecture. Chapter 6 provides guidance on adoption/ implementation. . Chapter 7 emphasizes the need to build capacities at scale on digital transformation and digital ecosystems. Illustrative examples of digital ecosystems are provided in the Annexures.

InDEA 2.0 Principles



2. InDEA 2.0 Principles

InDEA is not prescriptive. It seeks to establish an environment of co-creation by the community that shares a common understanding on the way the digital ecosystem should evolve. Such a common understanding can be conveniently articulated in the form of set of common principles all the actors in the ecosystem agree to adopt voluntarily.

InDEA 2.0 provides a superset of 27 principles organized into 5 categories listed below:

A. Ecosystem Principles
B. Architecture Principles
C. Business Principles
D. Technology Principles and
E. Architecture Governance Principles.

i. This superset is built upon the principles laid down in IndEA 1.0 and those adopted by large digital ecosystems like Aadhaar, GSTN and NDHB.
ii. Any organization or enterprise intending to adopt InDEA 2.0 can select a subset of these principles depending upon the requirements of the system/ ecosystem being architected.
iii. Once adopted, the principles will have to be held as sacrosanct by all the actors of the related digital ecosystem.

The InDEA 2.0 principles are listed and briefly explained below.

2.1 Ecosystem Principles

-that strengthen the ecosystem concept and enable interoperability and innovation.

2.1.1 Ecosystem Thinking:

*Design all digital initiatives as **ecosystems**, and NOT as **systems**.*

- Ecosystems span across Centre and States, public and private, and are composed of several autonomous, interoperable and federated systems.

2.1.2 Building Block approach:

Architect and design systems and ecosystems in terms of minimal and reusable Building Blocks.

- InDEA 2.0 categorizes the Building Blocks as Core, Common or Reference Building Blocks basing on the degree to which they are to be decentralized. (elaborated at the end of this sub-section)
- All the building blocks shall **evolve orthogonally**. Any change in any building block shall not require consequential changes to be made to the other building blocks.
- The building blocks shall interoperate via standardized, open, and stable interfaces.
- Building Blocks infuse reusability and interoperability into InDEA 2.0.
- Building Blocks designed and developed by the community and placed in the public domain reduce the effort and cost of development of common software components.

2.1.3 Open API-based:

*Adopt the principle of '**Open-API by default**'. Exceptions shall be justified.*

- The Open API Policy (https://apisetu.gov.in) and the guidelines issued by the Government of India shall be followed.
- Appropriate communities shall be promoted in various sectors of governance/ economy for developing Open APIs
- The specifications on Open APIs published by global organizations like OAS Foundation (Open API Specification) may be adopted as needed.

2.1.4 Open, Open and Open:

*Design the digital systems to be built on **open** source, to be published as **open** source, and to conform to **open** standards. Exceptions shall be justified.*

- The Policy of GoI on Open-Source Software shall be followed in all developments and procurements for e-Governance/ digital transformation projects.

2.1.5 National Portability:

Design national digital systems and platforms for portability across India.

- Factor the requirements of localization and diversity, inclusion, and special needs.

2.1.6 Participatory Design:

Drive participatory design and end-user engagement at all stages of the digital initiative.

- Establish a set of robust **rules of engagement** for the ecosystem players.
- Promote open communities on all major themes and major initiatives of e-Government and digital transformation.

2.1.7 Innovation:

Enable and promote innovation, and 'responsible' deployment of emerging technologies.

- Establishing an '**ecosystem sandbox**' can be good enabler of innovation.
- Data is the oxygen for innovation. **Data sharing policies** appropriate to various sectors shall be notified by the central and state governments, ensuring data protection requirements at the same time.

Building Blocks – the essence of InDEA 2.0

A building block is a package of business or technical functionality, which is reusable, stable and scalable. The concept of building blocks is central to InDEA 2.0. A building block has

- a business owner and a technology owner
- generic applicability
- stand-alone capability
- cross-functional usage

A building block is interoperable with other building blocks through well-defined and stable APIs.

InDEA 2.0 recognizes the following 3 categories of building blocks depending upon the combination of its attributes and the degree to which it is centrally positioned.

1. **Core building blocks**: which play a **pivotal and central role** in the enterprise system and hence occupy an extremely important position in the architecture. Because of their extremely useful functionality they are accessed by most of the other building blocks.
2. **Common building blocks:** which are most often shared assets play the role of optimizing the effort in design, development, and maintenance. They have the common minimum horizontal functionality to facilitate their use in a wide range of organizations.
3. **Reference building blocks:** which are most often in the form of tools that enhance efficiency and effectiveness. While they provide important functionality, they are not show-stoppers.

Table 2.1 compares the 3 categories of building blocks.

Sl No	Attribute	Core building block	Common building block	Reference building block
1	Qualifying criteria			
	2 Pan-government usage	Yes	Yes	No
	3 Pan-India usage	Yes	Yes	Yes
	4 Domain-neutrality	Maybe	Maybe	Maybe
2	Object type	Data or Middleware	Application or infrastructure	Tool
3	Flexibility to user	Rigid	Configurable	Configurable and customizable
4	Unique benefits/ value proposition	• Supports interoperability • Enables integrated services • Forms Single source of truth/SoR • Saves duplicative effort • Promotes innovation • Ensures consistency across the enterprise	• Saves duplicative effort • Provides uniform user experience • Incentivizes one-time process optimization, usage across enterprise.	• Enables specific value addition critical required by some organizations • Supports policy and M&E functions. • Enhances accountability
5	Ownership	Public Sector	Public sector	Public/ pvt sector
6	Design	Public sector	Co-design	Public/pvt sector
7	Development	Public sector	Outsourced	Private sector
8	Maintenance	Public sector	Outsourced	Private sector

2.2. Architecture Principles

- that advocate and promote decentralization, choice and technology independence.

2.2.1. Federated Architecture:

Adopt a Federated Architecture model for designing digital ecosystems – especially data and applications.

- Build around the constructs of **Single-Source-of-Truth** and **System-of-Records**, both of which should be created and maintained by the entity legally responsible to do the same. All other entities shall be required to access it from such a source/ record.
- The principles of Federation, outlined in Annexure 2, shall be adopted.
- These principles apply to databases, applications, identities and reference data; and to architectural and IT governance.
- A consultative approach shall be adopted in designing the architecture, involving all the stakeholders related to the initiative. These include the States, industry, academia, and the civil society organizations.

2.2.2. Agile Architecture:

Permit the architecture to evolve in an agile and iterative manner.

- Do not restrict or constrain the potential for innovation by being prescriptive when not necessary. Adopt the principles and methods suggested in **Agile IndEA Framework**.
- All artefacts are hosted online and evolved continuously

2.2.3. Technology Independence:

Architect systems to be technology-independent.

2.3. Business Principles (or Domain Principles) –

- that enjoin a value-driven, citizen/business-centric approach to architecture, design, and development.

2.3.1. Value-driven:

Focus on providing additional or new value to the user. Plan to Define, Design and Deliver value.

- Measure service levels (planned and achieved), impact and outcomes.
- Adopt the methods suggested in **Digital Service Standard**.

2.3.2. Integrated Services:

Identify, design, and deliver integrated services that cut-across agency boundaries, to realize the goal of Connected Government.

2.3.3. Outcome-driven:

Define service levels and outcomes benchmarking with the best, and then build services around such outcomes. Work backwards to re-engineer the processes - where necessary.

2.3.4. Choice:

Provide choice, by design, to the citizen.

2.3.5. Universal Access:

Ensure that the digital services are accessible to all the target groups, including those residing in remote areas and to disadvantaged groups.

2.4. Technology Principles

- that emphasize adoption of standards, optimal exploitation of digital assets and above all, user experience.

2.4.1. Cloud First:

Cloud shall be the first choice in taking ICT infrastructure decisions.

- In respect of applications, systems or data classified as *confidential* or *sensitive and confidential*, explore the option of going in for Government Community Cloud (GCC).
- In respect of applications, systems or data classified as *sensitive*, explore the option of going in for GCC or Virtual Private Cloud (VPC).
- In all other cases, go for public, private or hybrid cloud depending on the requirements of the domain.
- The Meghraj Policy of GoI (https://www.meity.gov.in/content/gi-cloud-meghraj) may be followed.

2.4.2. Mobile First:

Design the delivery of all digital services through mobile by default.

- Citizen-facing services shall have 'offline option' to include network-challenged geographies and should have versions compatible with feature phones.

2.4.3. Data is an asset:

Design data systems in a manner that creates, supports, maintains, and enhances value to the enterprise specifically, and to the ecosystem in general.

- Promote establishment of *Data Exchange(s)* that enable regulated exchange of data for public purposes, innovation, and research, and for permitted commercial purposes.
- Establish / promote robust data governance systems in conformity with the best practices

2.4.4. Data sharing:

Lay down clear data sharing policies specific to the relevant domain(s), that enable and regulate the sharing of data, in conformance with the applicable data protection regulations.

- Data sharing policies apply to public sector data
- Private sector may adopt the data sharing policies on a voluntary basis.

2.4.5. Standards:

Specify the existing technology and data standards applicable to the ecosystem and define methods to ensure compliance with the same.

- It is necessary to
    - Update the standards listed in IndEA 1.0 and establish a process for an annual updation.
    - Establish a framework for government-industry-academia collaboration for development of standards, protocols and specifications required for InDEA 2.0.

2.4.6. Privacy-by-Design:

Design and publish a privacy policy that conforms to the principles of Privacy-by-Design.

- Privacy-by-design implies adopting the nine principles listed below
    - Notice
    - Choice and consent
    - Purpose limitation
    - Collection limitation
    - Access and correction
    - Security
    - Openness, transparency and
    - Accountability

2.4.7. Security-by-Design:

Design and enforce a cybersecurity policy that conforms to the principles of Security-by-Design, and an ISMS (Information Security Management System) that conforms to the ISOs relating to information security.

- Security-by-design implies adopting the principles listed below
    - Minimize attack surface area
    - Establish secure defaults
    - Follow the principle of least privileges
    - Follow the principle of defence-in-depth

- Fail securely
- Don't trust 3rd party services
- Observe principle of separation of duties
- Avoid security-by-obscurity
- Keep security simple

2.5. Governance Principles

- that enhance trust, efficiency, and transparency of/ in the digital ecosystem.

2.5.1. Governance Systems:

Establish accountable, transparent, and effective institutional structures for

- Architecture Governance
- IT Governance
- Data Governance and
- Security Governance.

2.5.2. Capabilities:

Build requisite capacities and capabilities in individuals and organizations of the ecosystem.

- Capacity building programs should focus on ecosystem architecture, enterprise architecture, design thinking, agility, co-creation and outcome orientation.
- Capacities on InDEA 2.0 should be built at multiple levels in public and private sectors.
- Environment for co-design and co-creation should be actively promoted.

2.5.3 Business Model:

Design, develop or promote a policy environment that supports financially viable and sustainable business models based on value-for-money.

- Primarily in the sectors where government is the key driver of actual usage and the underlying standards, a policy environment may be created to enable the industry and innovator ecosystem to develop new business models based on additional value like convenience, personalization, cost-saving, faster/ time-bound/ instant service. The business models in the other sectors may be kept outside the purview of InDEA 2.0 and allow the market dynamics to work.
- Subject to the above, the model RFPs on public sector procurement and PPP should make specific provisions for enabling self-financing models of delivery of digital services.

2.5.4 Leverage the legacy:

Leverage the existing systems after assessing the degree of their conformance to these principles and enhancing them appropriately for strict conformance.

2.5.5 Implementation Strategy:

Think Big, Start Small, Scale Fast.

- An hourglass model of implementation is recommended. Details are in **Annexure 3**.

2.5.6 Enable rather than build:

Enable the ecosystem to design, develop and deliver digital services. *Build* only in exceptional cases.

InDEA 2.0 Architecture Patterns

3. InDEA 2.0 Architecture Patterns

The key drivers of InDEA 2.0 include **re-usability** of architectural components (termed as building blocks) across the digital ecosystem and **ease of developing an architecture** out of the 'architecture templates. The architecture templates are called Architecture Patterns in InDEA parlance.

A pattern is defined as: "*an idea that has been useful in one practical context and will probably be useful in others*" (Source: *Analysis Patterns - Re-usable Object Models*, by M. Fowler).

Pattern is a way of putting building blocks into context; for example, to describe a re-usable solution to a problem. Building blocks are *what* we use to architect. Patterns tell us *how* to use them, *when* and *why*.

InDEA 2.0 *makes architecting simple* by adopting the 'pattern approach'.

InDEA 2.0 comprises of three architectural patterns suited to different administrative environments, and a Master Plan that binds them together. These are explained in **Table 3.1**.

Sl No	Name of the Architecture Pattern	Capabilities, characteristics of the Pattern	Organizations which can adapt the pattern

1	**InDEA Master Plan**	• Hosts and maintains
		  ○ core building blocks,
		  ○ core data
		  ○ common building blocks
		• Enables inter-domain interoperability
		• Acts as the fountainhead of all architectural models through adaptation
		Acts as a repository of
		  ○ all artefacts of InDEA 2.0
		  ○ specifications and application code of reference building blocks
			• MeitY, GoI (develops and maintains the key components of the Plan)
			• GoI Ministries dealing with a central subject (with adaptation)
			• State government departments dealing with a state subject
			• CPSUs
			• Private organizations with pan-India presence and uniform processes

2	**InDEA Domain Architecture Pattern**	• Acts as the template for designing of architecture of the digital ecosystem of a domain (sector)
		• Enables interoperability within the domain,
		  ○ between centre and States
		  ○ between public and private sector and with other related domains
		• Catalyzes the evolution of a building block that can become gamechanger for that domain
		• Promotes innovation through ecosystem sandbox
			• GoI Ministries dealing with a concurrent subject
			• Private organizations with pan-India presence and localized processes

3	**InDEA State Architecture Pattern**	• Acts as the template for designing of architecture of the multi-sectoral digital ecosystem of a state.
		• Enables interoperability
		  ○ across all the domains within the State
		  ○ between the State and the Centre
		  ○ between public and private sectors
			• State Governments planning pan-Government systems, integrated services
			• Private organizations dealing with LoBs in multiple sectors

		• Supports development of integrated/ joined-up services	
4	**InDEA Lite Architecture Pattern**	• Minimum architectural effort • Focus on outcomes, interoperability • Quick results	• Small ministries and departments of GoI • Small departments of State Government

***Table 3.1** InDEA Architecture Patterns*

Figure 3.1 provides a synoptic view of InDEA 2.0 (* AP = Architecture Pattern)

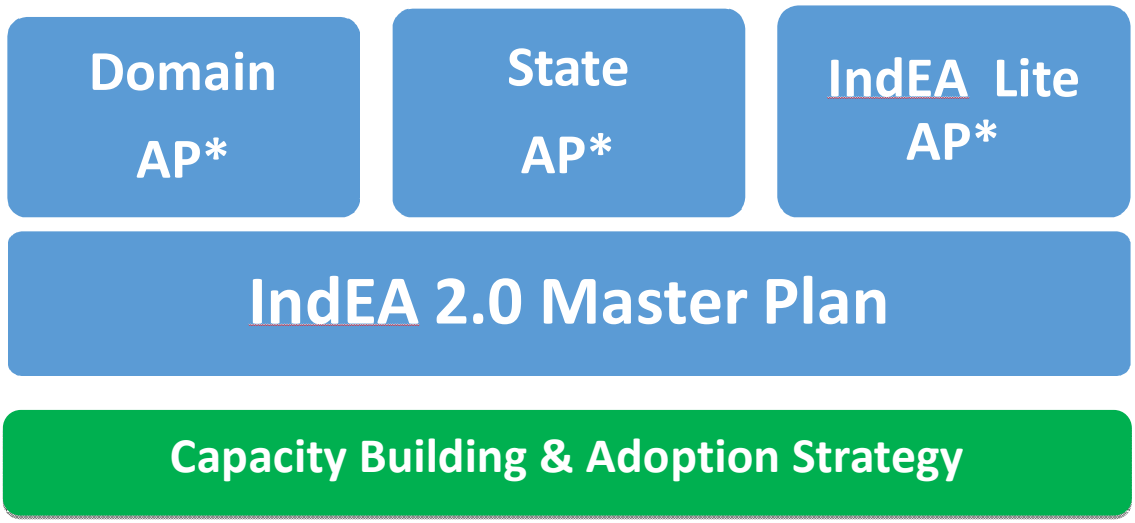


***Figure 3.1** Overview of InDEA 2.0*

A description of the Master Plan and the 3 architectural patterns with their salient features is given in what follows.

3.1 InDEA 2.0 Master Plan

Figure 3.2 provides an overview of the InDEA 2.0 Master Plan.

The rationale for the InDEA 2.0 Master Plan, and its features are given below:

a. InDEA 2.0 Master Plan is NOT an architecture or an architectural pattern. It is a **plan** (*akin to the master plan of a city*) that provides a *direction* to all initiatives for digital transformation – largely in the public sector, and in the private sector to the extent that their initiatives interface with the government.
b. Items 1 to 4 in Figure 3.2 are best designed, developed, and managed by MeitY, Govt of India. This would bring consistency and interoperability across the whole of Government – central, state, and local governments included. This would also result in saving of cost currently incurred in **duplicative efforts** by Governments all over the country, on these building blocks and applications.

c. Items 5 to 10 in Figure 3.2 are to be designed, developed, and managed by the rest of the ecosystem, consisting of GoI Ministries, State Governments, academia, and the private sector (including innovators).

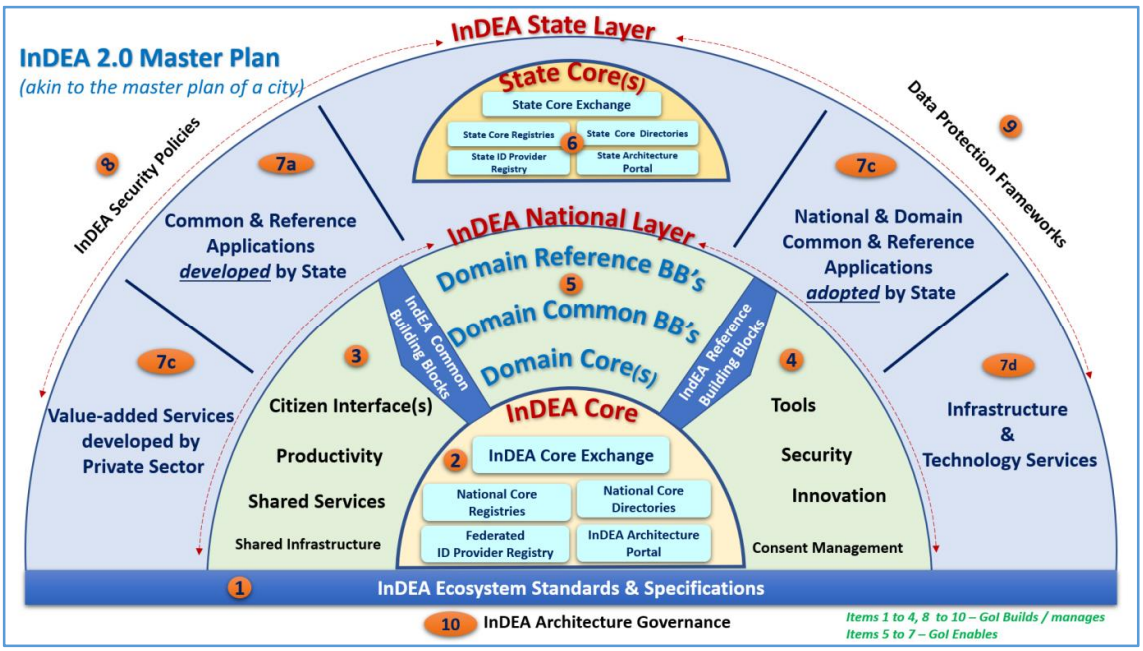


***Figure 3.2** InDEA 2.0 Master Plan*

d. **Figure 3.3** represents a detailed view of the items 1 to 7 of the Master Plan. There are altogether 10 Groups and 45 building blocks in the Master Plan.

e. Annexure 4 provides a cryptic description of the capability of each of the building blocks. Significant effort is required to undertake the detailed design of these building blocks, requiring the establishment of a specialized institution to guide the designs and oversee the implementations.

f. The following conditions apply to the Master Plan.
   i. The list of Groups (10) and building blocks (45) is non-exhaustive.
   ii. An organization / enterprise is not required to deploy all the building blocks but can choose what the domain needs.

g. Though the plan is represented in two dimensions, it is multi-dimensional because we have multiple domains (sectors) and multiple States. The set of domains and set of States is each represented by a single element of the set. **When designed fully over a period, the Master Plan can be huge in size and complexity**.

h. **Can InDEA 2.0 be a gamechanger?** The answer depends on how effectively the InDEA principles are assimilated by the domain experts and put into practice. InDEA framework itself is agnostic to any domain. Its inherent game changing potential is *technical* in nature and is limited to that achievable through interoperability and consistency across the government. However, the *true* gamechangers are born in the different domains / sectors by the efforts of experts who are passionate to address the fundamental issues and challenged faced by the sector by thinking laterally and by promoting innovation.

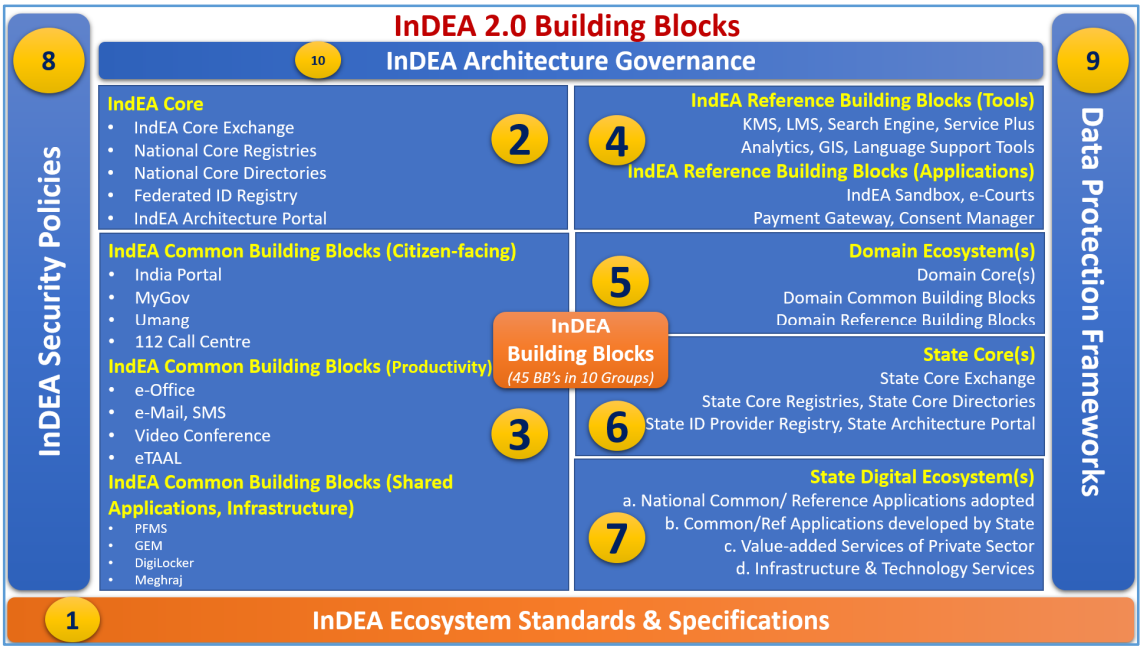


Figure 3.3 Overview of the building blocks of InDEA

3.2 InDEA Domain Architecture Pattern

The justification for the Domain Architecture Pattern arises from the fact that the basic architectural requirements of most organizations in the public sector are significantly similar. This pattern therefore abstracts the common and comparable requirements into a stereotype which can be adopted straightway as a starting point for any architectural effort. Quality time and effort can be devoted to innovation on the domain side. Customization, supplementation, and improvisation of the template provided by the pattern are necessary but may consume only incremental efforts.

Figure 3.4 represents the Domain Architecture Pattern (DAP). The salient features of the pattern and guidance on its use are explained below.

a. DAP applies to all the Ministries of Govt of India that deal with a concurrent subject i.e a sector in which both the central and state governments can legislate, govern and administer. DAP can also be used by the private sector organizations (i) that operate in a sector covered by the concurrent list or (ii) that have pan-India operations - possibly with some local variations.

b. Every domain (sector – like health, education, agriculture) shall have its own 'domain core', common building blocks and reference building blocks. The essential items of the domain core, common and reference building blocks are shown in Figure 3.4 on a non-exhaustive basis. The respective domains need to validate and supplement these building blocks.

c. A 3-layer architecture is suggested in DAP – core, national and state layers. This pattern enables interoperability across the country where needed, and leaves flexibility in the design and development of digital systems autonomously by the ecosystem players – public and private.

d. DAP is truly representative of the principle of federated architecture. The core registries and directories shall be designed in a truly federated manner whereby the data is created and maintained by the organization legally empowered to do so, and can be shared in accordance with the applicable data protection regime. Likewise, the common applications are codesigned or designed in consultation with the States to be closer to the ground realities.

e. Widespread adoption of DAP by multiple states enables dissemination and replication of best practices across the country.

f. DAP in conjunction with the principles such as open API and building blocks like data exchange would give a great fillip to innovation catalyzed by the access to data. Value-added services also get a boost through DAP.

g. Above all, DAP provides a fertile ground for new ideas, and can catalyze gamechangers to evolve anywhere and benefit the whole country. The incentive for innovation would be that the solution developed can scale rapidly and seamlessly in multiple states due to the interoperable environment within the same sector/ ecosystem.

h. NDHB (National Digital Health Blueprint), IDEA (India Digital Ecosystem of Agriculture), NDEAR (National Digital Education Architecture) and AG (Ayush Grid) are all founded on InDEA principles and are good examples of how a protype or pattern can help speed up the architecture development method.

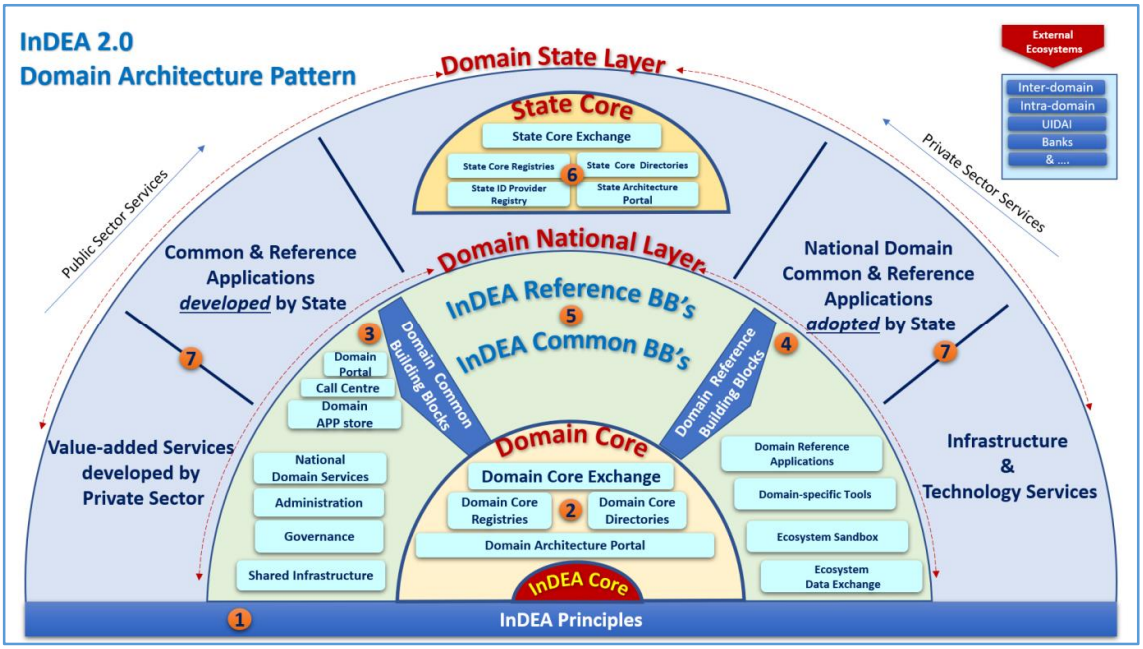


Figure 3.4 The Domain Architecture Pattern

3.3 InDEA State Architecture Pattern

The justification for the State InDEA Architecture Pattern (ISAP) arises from the fact that most of the citizen-facing services are delivered by the States and delivering the services in a consistent, efficient and integrated manner will result in substantial enhancement in citizen satisfaction. A State which has a well-designed, standards-based and open architecture in place shall be the focal point for convergence of digital transformation initiatives of several Ministries of GoI.

The ISAP pattern is represented in **Figure 3.5**. The salient features of ISAP are mentioned below:

a. ZA VAmong the 3 Architecture Patterns, ISAP offers the maximum challenge and potential for architectural effort because of the large number of domains (over 30) to be catered to, and the need for integration and interoperability o several fronts.
b. ISAP has been conceptualized as a 3-layer ecosystem consisting of a Core, Common Applications, and domain/ sectoral ecosystems.
c. The State Core acts as the focal point for integrating the applications at the State level but also of the central level.
d. One of the critical success factors of adoption of ISAP is to prioritize the Common and domain applications to be implemented at first. Ideally 2 to 3 common applications (preferably including HR and Finance) and 2 to 3 domain systems are taken up in the first tranche. This would enable reaping quick benefits of ecosystem architecture and propel further phases.
e. The State Core can leverage the common and reference building blocks developed at the national level.
f. Given the pivotal importance of the State Core, it is desirable that GoI promotes the development of State Cores in a few states as it can lead to significant architectural learnings and proliferation of the adoption of ISAP as well.

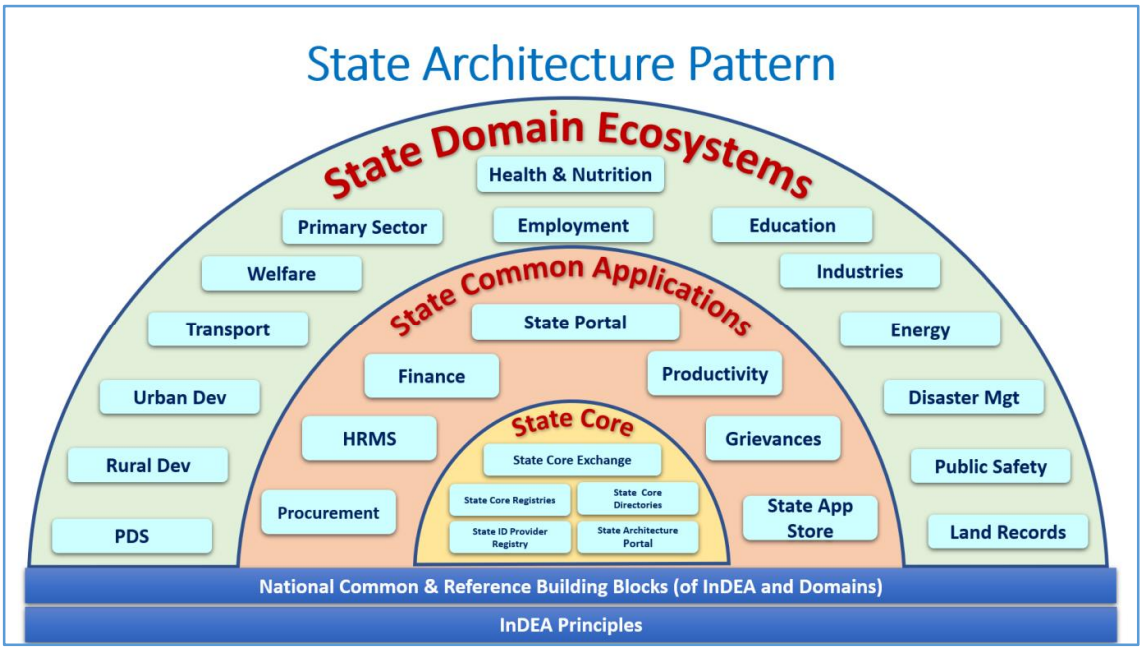


Figure 3.5 State Architecture Pattern

3.4 InDEA Lite Architecture Pattern

As the name indicates, InDEA Lite Architecture Pattern (ILAP) makes it possible to derive benefits of architecture in a speedier manner. It is the minimum viable architecture that can be taken up in a limited jurisdiction with limited functionality. The concept of gamechanger building blocks can also be attempted as a part of the adoption of Lite Pattern.

Figure 3.6 shows one of the possible models of the ILAP. The following are the salient features of ILAP:

a. InDEA Lite is meant for **departments of Central or State Governments** intending to adopt a holistic approach to their portfolio of functions, and to unify their legacy systems

- They can go on a stand-alone basis **at their own pace**, without any dependencies

b. InDEA Lite provides a **quick route** to produce holistic results. (6-9 months!)

c. InDEA Lite pattern guides the dept though its **layered approach**

- 3 layers for GoI Depts (National- State- District levels)
- 2 layers for State Departments (State-District)

d. The application architecture adopts 2 architectural concepts:

- Common Applications & Domain-specific applications

e. InDEA Lite **does not mandate Building Blocks model**

- However, the department can pick and choose the relevant building blocks available at National/ State levels.

f. InDEA Lite provides flexibility to develop/ integrate applications at any of the 3 levels, **independently of the other layers**.

g. <u>The only mandate of InDEA Lite is to follow the InDEA Principles to the extent applicable (the '**Reduced Set**')</u>

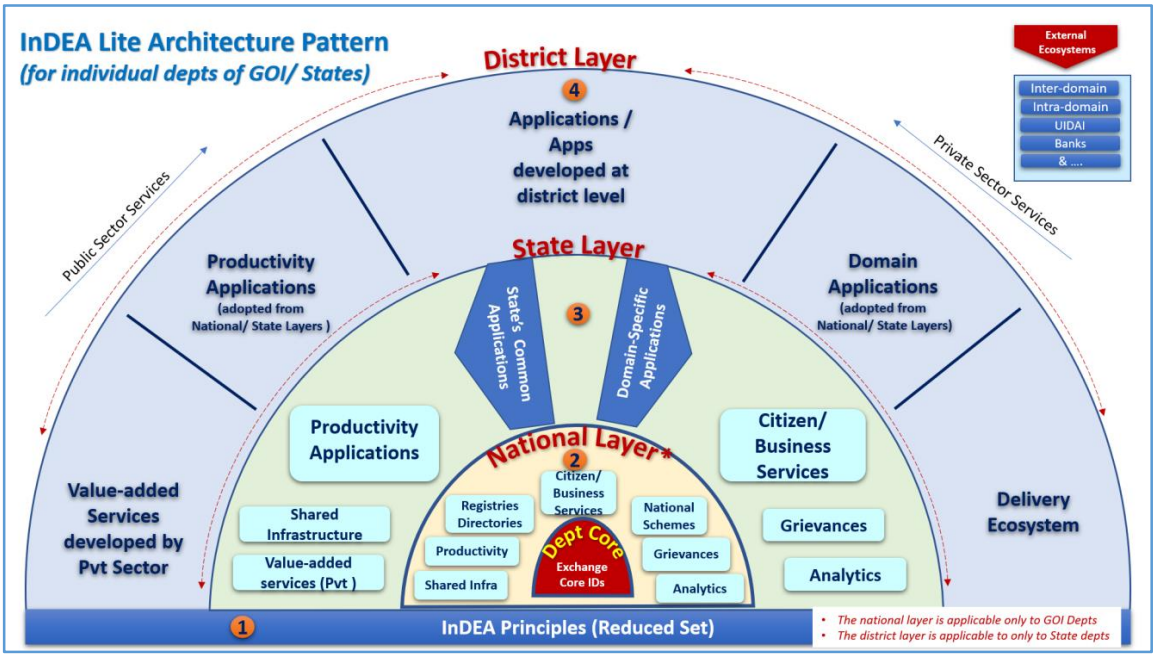


***Figure 3.6** InDEA Lite Architecture Pattern*

Federated Digital Identities

4. Federated Digital Identities

4.1 The Big Picture of Digital India

4.1.1 Digital Transformation in India

Through 2000 to 2010, India's mobile operators with the support of the Government and regulator, transformed the access reaching a billion mobile connections within a decade. With the advent of affordable smartphones and high bandwidth mobile networks, India has one of the largest Internet and smartphone user bases.

4.1.2 Aadhaar & India Stack

Although India's mobile access was booming, By 2009, India was spending around Rs.3 trillion in benefits and entitlements. At the same time, in 2009, India's banking access was still below 20% and a low percentage of people had access to a nationally portable ID. In 2009, India began the Aadhaar project, now covering over 1.32 billion Indian residents, doing 1 billion plus authentications every month, providing a true foundation for Government Direct Benefits Transfer (DBT) and Jan Dhan financial inclusion programs.

Subsequently, India built a set of federated digital building blocks as public infrastructure, collectively known as India Stack, which included APB, AEPS, eSign, Digilocker, UPI, and DEPA (a decentralized consented data sharing protocol) based on which new data networks such as Account Aggregator and Personal Health Records are being activated.

4.1.3 Empowering Citizens and Businesses

When systems/platforms - both public and private - are in the middle enabling people and small enterprises, it is essential to ensure people and especially small businesses are empowered to have meaningful choice and opportunities.

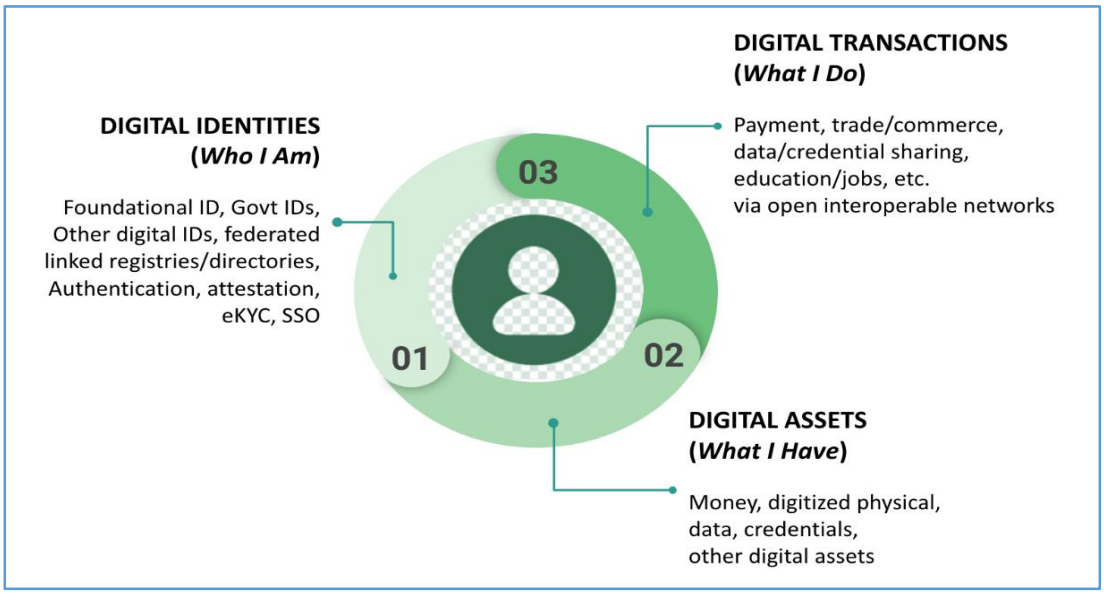


***Figure 4.1:** Three core aspects of a Person's/Entity's Digital Life*

Figure 4.1 depicts the three core interlinked aspects of a person's/entity's digital life, explained below:

1. **DIGITAL IDENTITIES (*Who I am*)**: This provides the ability for people and businesses to ascertain their identity, authenticate themselves, do KYC (share profile), and manage the lifecycle of those IDs. It is important to note that there will be multiple digital IDs co-existing each having different purposes and levels of assurances. For example, people may have a strongly verified unique ID like Aadhaar, mobile/email,and other online digital IDs that are used in social media etc. Which ID can be used for what service depending on the provider of that service, for example, opening a bank account may necessitate a strongly verified Government issued ID, while booking a hotel may only need an email or phone number verification.

2. **DIGITAL ASSETS (*What I Have*)**: As a person (or an entity) participates in various transactions in their life, they earn/accrue various assets such as money, property, other physical assets, digital assets, etc. But two additional assets that must be taken into account are data and credentials. In India, with the new data protection bill, every person will have the right to own their data and credentials. Not only that they can own, they can use data as asset, share with consent, and leverage to access various services such as jobs, loans, etc. Credentials (various certificates in digitally verifiable form) enable people and entities to make claims about them (e.g., claims about academic degree or work experience) for availing services and the service provider having the ability to verify those claims in a paperless and trusted manner.

3. **DIGITAL TRANSACTIONS (*What I Do*)**: Once the person can digitally authenticate and leverage their assets in their control, they participate/engage in various interactions/transactions throughout their life, in turn, trading/earning assets. In the digital realm, these transactions are conducted via various platforms, be it a public or private platform. These platforms enable consumers (who are seeking the service) to connect with the providers (who are providing services). But, as transactions increase, these platform providers become, in one sense, the gatekeepers of it, thus reducing the choice and portability. It also creates "winner take all" and anti-competitive behaviour. Notice that irrespective of whether a platform is provided by Government or a private player, concentration risk and reduced innovation sets in. Also given the scale and diversity of India, no single platform can solve for all. A new way to think about this is to allow multiple platforms to co-exist, but ensuring that these platforms form a 'unified interoperable network' through the use of "open protocols". India with its highly successful payment networks such as Unified Payment Interface (UPI) and Account Aggregator (AA) networks, upcoming Open Network for Digital Commerce (ONDC), Unified Health Interface (UHI), and other similar efforts across domains is leading the world by showing how a vibrant ecosystem can thrive, interoperate, and still provide choice for participants and level playing field for the innovators.

This chapter specifically covers architecture and recommendations for digital IDs and linked federated registries. It may be recalled that Federated registries of ID constitute one of the core building blocks of InDEA 2.0. Further aspects of digital empowerment with respect to data & credentialing and open ecosystem networks along with architecture and recommendations are discussed in the Chapter 5.

4.2 Digital IDs and Electronic Registries

4.2.1 Context

In India, digitization of various Government and market systems is happening at a fast pace across all domains such as healthcare, agriculture, education, commerce, etc. With a large number of people having Aadhaar, mobile, Internet connection, citizen interaction/transaction data are stored digitally across all these systems. When interactions/transactions are conducted, some form of digitally verifiable ID of the "participants" of those transactions are captured along with the transaction record. Typically these are in the form of Aadhaar or mobile or email or PAN or other verifiable digital identifiers.

To ensure inclusive development, any system (especially Government platforms) must be designed to include people from all walks of life including people with no access to phones, Internet, etc. Given India's large diversity and widely varying education levels, it is also essential that architecture of Government systems must support diversity and be inclusive.

As various Government platforms across domains are being digitized, there is a tendency to create more IDs each with its own ID card, ID management, and effort to make it unique, etc. Having a multitude IDs, especially to interact with the Government, makes it harder for common man for whom these are created! Especially given the diversity in education, awareness, and capabilities, this also has a potential to further create exclusion scenarios.

While the intent of the State is to care for the vulnerable and poor, systems must still be designed to provide agency and choice to people. At the same time, architecture must make it easy and convenient for people to participate and access their documents, data, entitlements, etc.

4.2.2 Understanding Uniqueness

It is common to make sure ID is unique to a user and also common to issue a “unique ID card” for specific purposes.

There are fundamentally two different lenses through which the concept of uniqueness can be seen - from user perspective and from state perspective, as differentiated below:

User Controlled Uniqueness	State Controlled Uniqueness
1. I have an ID that is unique TO ME and ONLY TO ME (mobile, email ID, bank account No, etc are all unique to the user) 2. I can choose to create two IDs both of which are unique to me 3. I can link my records to any of the unique IDs I have easily 4. I can keep my records private	1. You can have one and only Unique ID (Aadhaar using biometric to de-duplicate) 2. You cannot have two IDs even if you wish to do 3. Your records will be linked to only one unique ID 4. You cannot remain anonymous from the state point of view

It is important to note that, in India, the only universally covered unique ID (that is globally unique) is Aadhaar due to its use of multi-modal biometrics and universal coverage. Under the Aadhaar Act and regulations, Aadhaar can be used for the Government programs where

Government is spending money to provide such services in addition to using for tax/AML compliance.

While domain specific platforms are popular, it is important to leverage the JAM identities as the universal IDs that are already used by almost everyone in India. It is thus recommended that other Government systems trying to create a "state controlled'' unique ID are encouraged to achieve it through Aadhaar authentication and eKYC. But, if that system is creating a "user controlled" ID, then, typically the user is allowed to use mobile number/email etc as a means to sign in.

Either way, such linkages allow citizens to onboard themselves and manage their account using common IDs such as mobile numbers or Aadhaar numbers that they are already using every day.

4.2.3 The Need for Registries

All digital platforms require master data and actor (person/entity/thing) data related to that system to be maintained for identification, validation, etc. For example, a property tax system needs to maintain master data about properties, the PDS system needs to maintain master data about the beneficiaries and so on.

As the world becomes data rich, it is essential that various data about people, entities, geographies, resources, assets, etc. are made available in electronic registries with Open APIs for other applications to seamlessly validate and use attested and authenticated data. This is even more critical when it comes to people and entities where various claims can be electronically validated against such registries via open APIs avoiding paper-based validations, thus increasing trust while decreasing cost of validation.

In this document, the word "Electronic Registry" is used to depict a trusted system that enables consented subjects (people, entities, things) to enrol, manage their record with necessary levels of verification, and avail 3rd party services built on it using its authentication and KYC services.

Aadhaar is a registry of "usual residents of India", PAN system is a registry of "persons (people/entity) who are direct taxpayers", PDS database is a registry of "people (and families) who receive food subsidy", and so on.

4.2.4 Digital ID as a key to a Registry

A Digital ID by itself does not independently exist nor has any stand-alone benefit unless accompanied by appropriate trust levels and used by other systems using authentication and consented profile sharing (KYC) service.

A digital identifier, therefore, is the "key" to a registry where the subject (ID holder) is present who, in turn, is empowered to control her ID, manage the registry record (her profile in that registry), choose to use it for availing other 3rd party services through authentication and consented eKYC (digitally signed profile sharing).

In every registry it is necessary that the subjects in that registry are "identified" in a unique and trusted fashion. These identifiers may be purely numeric (e.g. Aadhaar number, mobile number, health ID within ABDM, etc.) or alpha-numeric (e.g. PAN number, Vehicle number,

email address, UPI Address, etc.) with or without any logic attached in generating the identifier itself (random vs logic based identifier).

Depending on the policy, uniqueness can be either "user controlled" (user may have more than one ID within the same registry, say, using two different mobile numbers) or "state controlled" (by linking the ID to a globally unique ID like Aadhaar, and hence making sure a user has one and only one entry within the registry).

Custodians of such registries should ensure appropriate policy is applied to either allow user controlled uniqueness or state controlled uniqueness. In addition, the fields in the record of that subject are to be verified/attested or marked as self-declared. When registering, people must be given an option to use their existing digital IDs such as Aadhaar, mobile, etc as appropriately to fit the purpose of that registry and also allow people to control, update, manage their record using the common IDs such as Aadhaar, mobile, etc.

4.2.5 Federated Registries

Many registries stand alone while some get interlinked via registry IDs **depending on the policies that allow such linking**. But, when it comes to delivery of benefits, in addition to usage of Aadhaar, interlinked registries within a state may be required to provide a unified view of benefits delivery.

Word "linking" is used in the technology context. It can mean

(i) one registry adding another registry's ID to its records after appropriate user authentication.

(ii) One registry or system trying to validate the end-user by using the entry of the end-user in another registry through an API

Any such linking in both the scenarios should be compliant to appropriate p

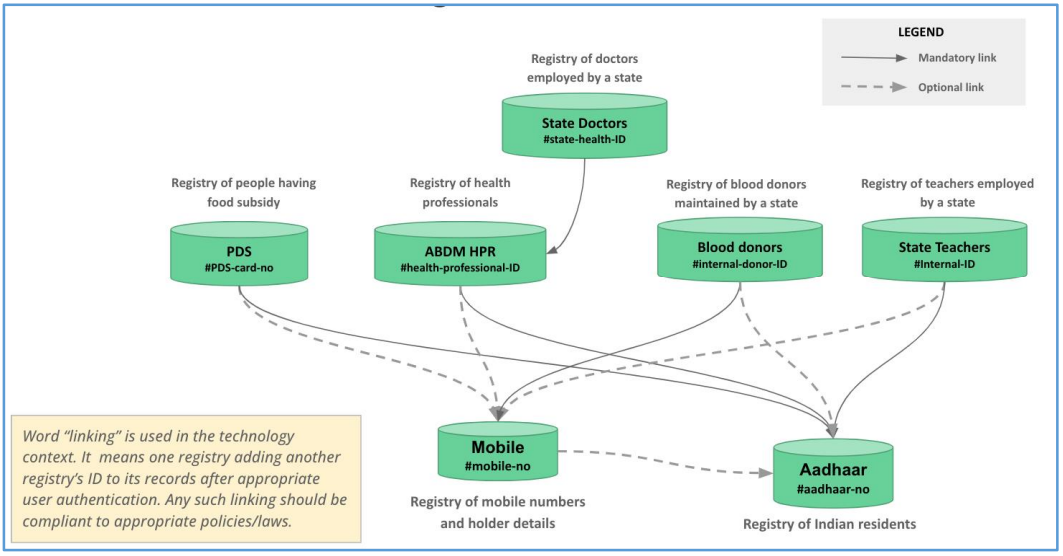


Figure 4.2: Illustrative example of federated registries

Technically, electronic registries can be linked via the IDs to allow easy, paperless on-boarding of citizens and also avoid repeated data verification needs. For example, when a beneficiary is registered for, say, PDS scheme, that record will be linked to Aadhaar by the PDS system storing the Aadhaar number (or a tokenized version of it). Similarly, when someone obtains a PAN, that record gets linked to Aadhaar where the Aadhaar number becomes the linking ID. Then when that person obtains a mutual fund account, PAN number, in turn, gets linked to the mutual fund record.

Ability to reuse an existing registry (under appropriate policy/law) of pre-verified attributes is critical to eliminate this repeated verification process that is costly, error prone, and most importantly inconvenient to citizens.

When a registry allows users to use "existing IDs from other registries" to be used as an authentication mechanism, it not only creates an "auto verified/attested" set of fields in the new registry (registry provider does not have to re-verify those fields again), but also gives convenience to the people to reuse and leverage commonly used IDs. This fundamental design pattern is what allowed Aadhaar to become a "building block" for other systems allowing banks to open accounts with eKYC (attested common fields coming from Aadhaar in digitally signed manner) and allow transactions with authentication.

To achieve this, it is essential that all registries are built to allow single sign-on (SSO) using existing IDs in other registries as well as expose itself as a SSO provider for the next set of systems.

4.2.6 Authentication and eKYC

To allow registries to be "reused" as "sources of truth" in a paperless and trusted manner for the sake of simplifying citizen service delivery process and reducing costs, it is critical that all registries provide the choice to the subject (person) authentication/Single-Sign-On and eKYC (consented digitally signed profile sharing) capabilities using the primary ID of that registry.

4.3 Recommendations on Federated Digital Identity Ecosystem

The approach suggested in this chapter for creation of federated registries eventually results in an "***optimaly set of federated digital IDs***" . The design is privacy -respecting, provides choice, and still allows citizens to use a few of their preferred IDs for various purposes.

Following are a set of recommendations for establishing federated digital ID and registries:

1. Under the federated architecture approach of InDEA 2.0, it is important to create a "federated set of registries", each of which is meant for a "specific purpose" rather than a universal, all-inclusive registry.
    a. Given the federated nature of service delivery and Government systems, it is essential that each registry be maintained in an autonomous way with its own workflows, purposes, rules of participation, etc.
    b. Any registry provider/custodian must design the registry with the subject (person) in the centre and ensure convenience, inclusion, data empowerment, and meaningful choice for them to control and manage their own record within the registry.

   c. All registry providers/custodians must ensure personal data protection and consented access fully and ensure appropriate security and privacy measures to protect the data within the registry.

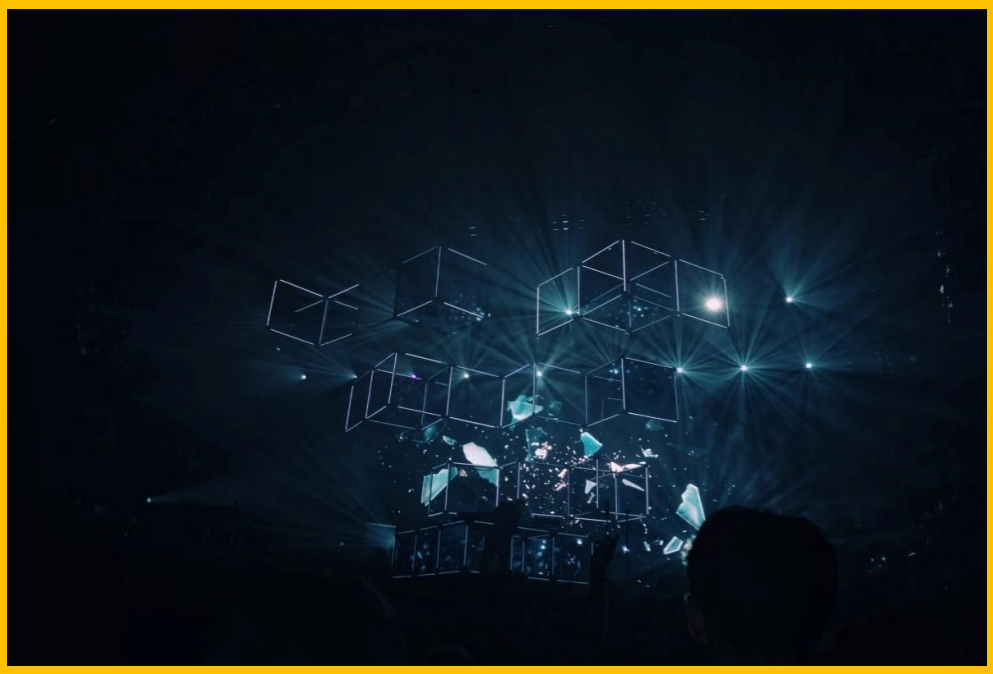
2. All such registries should have their own "digital ID" internally to uniquely identify a record.
   a. These internal IDs should ideally be "user managed" (like a "user ID") making it easier for them to remember and reuse.
   b. If not, a random number may be used with an option to attach a user ID.
3. Handling uniqueness:
   a. When global state-controlled uniqueness is necessary, allow users to link their Aadhaar or other Aadhaar linked or Aadhaar derived or Aadhaar based digital IDs to achieve it.
   b. If not (if it is user-controlled uniqueness), then allow common identifiers such as mobile numbers or other acceptable Digital IDs to be used and still allow users to voluntarily use their Aadhaar.
   c. This allows minimizing the need to remember and use many IDs by the citizens and provides convenience of managing their account using either Aadhaar or mobile or other acceptable digital IDs.
4. Authentication, eKYC, and SSO:
   a. All registries should be built as a "building block" to be "reused" as "sources of truth" in a paperless and trusted manner for the sake of simplifying citizen service delivery process and reducing costs
   b. All registries should offer authentication/Single-Sign-On along with eKYC (consented digitally signed profile sharing) capabilities using the primary ID of that registry
   c. The SSO should cater to cross-domain and should facilitate identity management among multiple SSO providers. SSO mechanism should be resilient enough to handle multiple point of failures. Also, it should identify and address security breach in SSO in proactive and reactive manner systematically.
   d. All registries should accept and allow citizens to enrol and sign-in with other available digital IDs (white listed as per their policies) to provide 1-click enrolment and sign-in for citizens.
   e. Items b & c above ensure that the registries are not siloed and stand-alone systems, but a true digital building block for other systems, providing citizen convenience and eliminating repeated data capture and verification complying with appropriate policies/laws.

In addition to the above, the following are also recommended to be explored by ID providers:

- Explore and leverage international open API specifications such as OpenID, oAuth, etc., when possible, to make it easy for interoperability of multiple -registries.
- Encourage use of e-Pramaan, Digilocker IDs as "authentication and SSO" mechanisms for others to leverage and provide convenience for citizens.
- All Government ID providers are highly recommended to explore the feasibility of creating an ID alliance to bring coherence, interoperability, and reuse among those keeping citizen choice, convenience, and control at the centre

- ID providers should evaluate and adopt NIST Guidelines on Digital ID[1] for establishing standardized trust levels across verification, authentication, and federation.
- The principles of federated architecture set out in Annexure 2 for governance of the digital ID ecosystem.

Emerging Trends in Ecosystem Architecture



5. Emerging Trends in Ecosystem Architecture

5.1 Citizen Impact on Digitization

When systems/platforms - both public and private - intend to be ceitizen- business-centric, in, it is essential to ensure that people (and small businesses) are empowered to have choice and opportunities.

Attention is invited to Figure 4.1 depicted in the previous chapter on Digital Identities, where the idea of using IDs to earn / accrue / control / leverage digital assets, and ability to participate in open transaction networks are discussed.

InDEA 2.0 implementers must necessarily be cognizant of all the three aspects of Digital Empowerment and therefore not only implement federated digital IDs, but also address the aspects of data & credential, and when possible facilitate and enable an open interoperable network within their domain.

Rest of the sections below deal with the architecture and recommendations for (i) data empowerment (ii) credentialing and (iii) open ecosystem networks.

5.2 Credentialing and Data Empowerment

5.2.1 Context

Every person (or an entity) participates in various transactions in across many platforms, leaving digital footprints across such platforms. They also earn many certificates, badges and other credentials. Unfortunately, in most cases, neither these credentials are available to them in digitally verifiable fashion nor the related data is available to them in a unified and trusted manner. It is necessary that both data and credentials are made available to its owner in a digitally verifiable form and in their control for subsequent use.

5.2.2 Personal Data Empowerment

In India, under the new data protection bill, every person will have the right to own their data and credentials. Not only that they can own, they can use data as asset, share with consent, and leverage to access various services such as jobs, loans, etc.

It is essential that all platforms adopting InDEA acknowledge this and design to provide machine readable personal data access back to individuals.

5.2.3 Principles & Architecture

Global conversation around individual privacy and data ownership has been happening in the last decade due to rapid growth in digitization. Legislations such as the General Data Protection Regulation (GDPR) in the EU, Open Banking in the UK, and the California Consumer Privacy Bill in the USA are all designed to give the individual agency and control over their personal data. Data Empowerment and Protection Architecture, or in short, DEPA[2]

[2] NITI Aayog page on DEPA - https://www.niti.gov.in/node/1299

is the technology foundation for India for creating "a secure consent-based data sharing framework".

NITI Aayog paper[3] articulates the need, value, and the necessity for having a technology infrastructure like DEPA to implement the data access and sharing part of the data protection bill.

Architecture of DEPA is shown below:

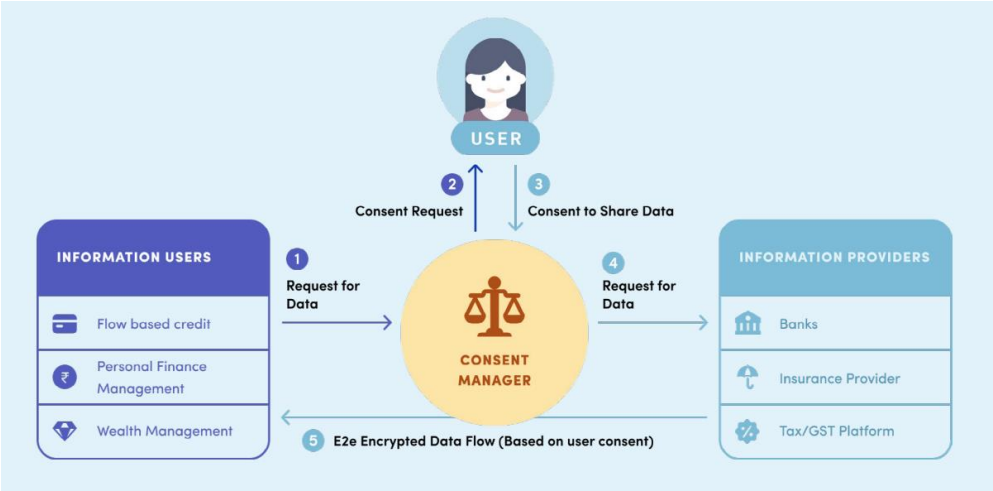


Figure 5.1: DEPA High Level Architecture illustration for financial data (from NITI Aayog Paper)

5.2.4 *Verifiable Credentials (VC)*

The government, academic, industry, and other ecosystems today issue many certificates (government and non-government issued), licenses, authorization letters, etc. Unfortunately having all these in paper form creates issues of low trust, information asymmetry, costly verification procedures, and non-portability amongst many others. In addition, authenticity of such documents is not easily verifiable giving rise to fake certificates and fraud.

Establishing a system of standardized VC documents enables an individual to easily share credentials in a trusted manner anywhere and thereby open up possibilities to access various opportunities and services.

Given India's successful Digilocker implementation, it is time for other ecosystems like skill development to ensure all certificates/credentials are issued digitally still allowing printability and inclusive usage.

Credentials (various certificates in digitally verifiable form) empower people and entities to make claims about them (e.g., claims about academic degree or work experience) for availing services and the service provider having the ability to verify those claims in a paperless and trusted manner.
India's Co-WIN platform is a great example of population scale implementation of W3C and WHO:DD compliant vaccine credentialing.

[3] NITI Aayog paper on DEPA - https://www.niti.gov.in/sites/default/files/2020-09/DEPA-Book.pdf

5.2.5 *Principles & Architecture*

The architecture and principles described below are adapted from recent efforts in the skilling and education sector under NDEAR and NDEAR-H and from the efforts of Co-WIN (vaccination credentials).

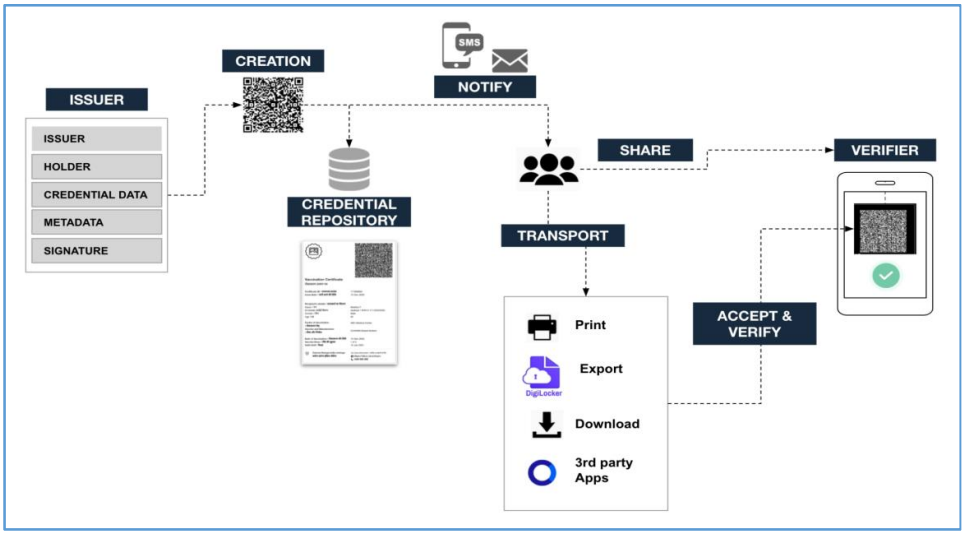


Figure 5.2: Credential Issuance & Verification - High Level Architecture

In order to achieve its objectives, the electronic credential should enable the following:

1. **Verifiability**: Authenticity of the credential should be digitally verifiable by any application to which it is presented in a paperless and presence-less manner. This verification should not require the physical presence of the credential holder or be contingent on any human action of the issuer.

2. **Portability**: To ensure empowerment and choice for the credential holder, the credentials should be digitally portable across systems participating in the ecosystem. As in the case of physical certificates, unrestricted usage by the holder should be enabled. This includes easy digital storage of choice of the holder and easy consented sharing for various purposes that holder deem fit.

3. **Permanence**: The credentials should continue to exist and be valid beyond the lifetime of the institution where it was awarded. That is, if a training agency which has awarded a credential subsequently ceases to exist, the credentials still remain verifiable and portable across the ecosystem.

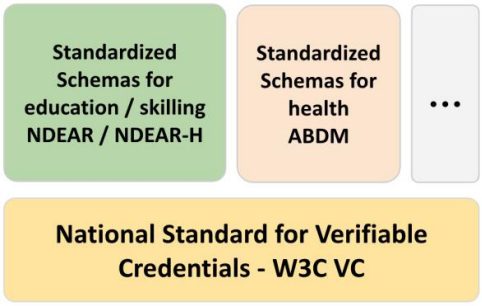
4. **Self-Describing**: The credential model should be self-describing in a manner that the verifier of the credential does not require private sources of information to validate or understand it. In practice, this means that all metadata, common identifiers, taxonomies, etc should be publicly accessible in various registries.

5. **Consent-based**: Design must ensure privacy preservation across the system including taking holder's consent for collection and use.

6. **Inclusive**: Design of credentials must ensure inclusion in terms of digital and physical usage (through printed modes with signed QR codes etc.), multi-lingual support, online and offline usage, and work seamlessly with inclusive and accessible technologies.

5.2.6 Recommendations on verifiable credentials

Credential Standards: InDEA 2.0 proposes to adopt a common electronic, machine-readable specification to represent various credentials/certificates across the ecosystem.



For verifiable credential, InDEA 2.0 will leverage internationally acceptable specification W3C VC[4] for all digital verifiable credentialing.

On top of W3C VC, to ensure domain interoperability, it is highly recommended that various domains create standardized schemas by aligning and adopting existing open source schema efforts. Diagram depicts the 2-layer standards approach.

Credential Issuance: Various systems implementing VCs as per InDEA 2.0 should set up credential issuance platforms (ideally by using existing open source implementations - see DPGA registry[5] for globally available implementations - which is recommended for Government systems or using commercially available implementations) to issue standard schema based W3C VC complaint credentials, give choice to users to download it, access via Digilocker, and also via any additional channels such as emails, instant messaging platforms, blockchain based systems, etc. Such issuance platforms should provide both natively digital formats along with a printable format which contains a digitally signed QR code. In addition, a process for issuance through revocation (as necessary) be implemented in such platforms.

Data Empowerment: Platforms implementing InDEA 2.0 should also implement DEPA architecture for all personal data access (including transactions, audit data, etc.) so that the individual/subject can access their data in a machine readable and digitally signed manner. Such consented access should be based on MeitY personal data sharing and consent principles. While implementing InDEA 2.0, systems should build core personal data APIs (Information Provider APIs) internally and start allowing users access it via a user interface built into those platforms. That allows InDEA 2.0 implementers to empower users with data even when an external consent manager and a data network is not yet in place. And when an open data network and consent manager falls in place, these same APIs can be then used to allow users to access their personal data through other applications as well.

[4] W3C Verifiable Credentials - https://www.w3.org/TR/vc-data-model/
[5] Digital Public Goods Global registry - https://digitalpublicgoods.net/registry/

5.3 Platforms to Protocols

In any organized society, the need to connect consumers and providers for conducting various transactions existed. This is especially true when the system is fragmented and disconnected. This discovery and connection asymmetry was typically solved by a "middle man" connecting both sides. Brokers in the physical world, yellow pages in the print world, etc are classic examples of a 2-sided "platform"! In the digital world, "a market/transaction platform" connecting consumers and providers on the same platform took charge.

5.3.1 The Need

Such a platform becomes a "***store of value***" and when they grow large, they become a concentration/monopoly risk. This is true even when the Government is running a monopolistic platform. In addition, such dominance created anti-competitive behaviour where the platform intermediary starts charging higher fees/tax for transacting on their platform. This fundamentally reduces the choice especially for providers, be it an individual or a small business.

But, if we look at the World Wide Web or Email, we see a different picture. We see multiple platforms connected co-existing and interoperating allowing any browser to view any website or someone to send email through one service provider to a recipient on another email service. This is because of the underlying "open protocols" (such as HTTP or SMTP) that enable such "*networks of platforms*" to interconnect and interoperate. These networks enable "***flow of value***" using these open protocols and bring out a much more decentralized ecosystem architecture. India's mobile phone network is another classic example of this where many providers can interconnect seamlessly due to underlying open protocol (GSM).

The following figure depicts the difference between a "platform approach" and "protocol approach".

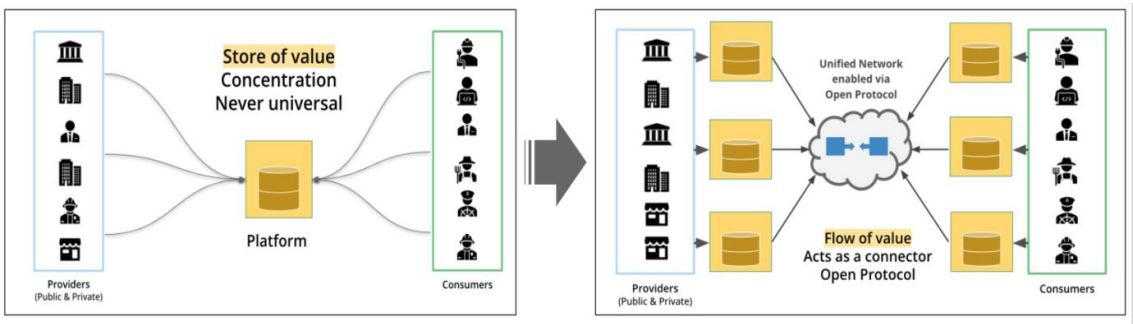


Figure 5.3: Platforms to Protocols

InDEA 2.0 fundamentally is an ecosystem architecture that is federated. When it comes to transaction systems, many times, Government departments or ministries wanting to induce innovation and interoperability across the ecosystem, can achieve that merely by adopting "*open protocol specifications*" and "*facilitating an ecosystem open network*" instead of setting out to build yet another platform.

5.3.2 Open Ecosystem Networks

Solving a problem at such a population scale obviates a paradigm shift from '***central platforms storing and exchanging value***' to a '***decentralised network of interconnected ecosystem actors orchestrating flow of value***'. Instead of an operator-driven monolithic platform-centric model,

there is a need to initiate a facilitator-driven, interoperable decentralised network using open protocols.

Given India's federal structure, growing startup ecosystem, and diverse usage scenarios, it is essential that Government departments and ministries look at facilitating open ecosystem networks via open protocols that allow many applications and many platforms to co-exist, give choice to consumers and providers, and drive innovation and growth while preserving interoperability.

5.3.3 Open Networks in India

India has already started reaping the benefits of creation of such open ecosystem networks that allow many applications and platforms to interconnect and interoperate seamlessly using open protocols. Following table gives the current and upcoming networks.

Network Name	Network Description	Open Protocol	Facilitator Organization
eSign	Instant digital signature service for a billion people built on an open protocol (APIs)I approach allowing any application to connect to any eSign provider in an open and interoperable way.	eSign	cca.gov.in
UPI	Unified Payment Interface - enabling interoperable instant payment across banks, wallets, merchants, apps, and other systems in a seamless way.	UPI	npci.org.in
AA	Account Aggregator network is a financial consented data access and sharing network. It was created through an inter-regulatory decision by RBI, SEBI, IRDA and PFRDA through Financial Stability and Development Council (FSDC). RBI licenses the AAs.	DEPA	sahamati.org.in
PHR ***(upcoming)***	Personal Health Records network is an open network using a consent manager framework to enable individuals obtain their health records and provide consented access.	DEPA	nha.gov.in
KOMN	Kochi Open Mobility Network – an open mobility network connecting various modes and providers (taxis, auto rickshaws, metro, buses, etc.) through an open protocol to many consumer apps.	Beckn for Mobility	KMTA – openkochi.net
ONDC ***(Upcoming)***	Open Network for Digital Commerce - an effort launched under the leadership of the commerce ministry to create a decentralized commerce network for various types of commerce in India. Currently in early pilot mode.	Beckn for Commerce	ondc.org
UHI ***(Upcoming)***	Universal Health Interface - an open network to unify health and wellness services and enable interoperable discovery through fulfillment of various health and wellness services.	DHP (Beckn for Health)	nha.gov.in

5.3.4 Implementing an Open Network

As described above, open protocols and specifications are critical to drive such networks. But, definition of protocols and specifications require deep technical understanding, domain knowledge, as well as understanding of how abstracted layers work in such protocols.

It is thus important for Government agencies adopting these to adopt existing open source protocols or work with the relevant communities to adapt and enhance as needed. By adopting open protocol specifications ideally built by an open-source community, these networks are driven by openness and interoperability as key principles.

While technology implementation of such open networks is possible by adopting the open protocol as digital commons, it also requires a mechanism to manage, co-ordinate, incentivize, and evolve the nationwide adoption and long-term sustenance of such open networks. It is therefore important to define a governance framework that is formed and informed by the purpose of the network. The approach of the RBI in this area may be examined in this context.

5.4 Recommendations on protocol approach

Open Network: When there is a need to connect a large ecosystem of providers and consumers to enable transactions, facilitate and create an open protocol based decentralized, but, interoperable network instead of a central platform.

Adopting Protocol: To explore working with the communities to adopt existing open source protocols to ensure a sustainable development and rapid adoption.

Network Facilitation: Enable creation of a participant driven, co-opted, not-for-profit entity to facilitate and run the network to ensure network adoption, growth, trust, health, and overall sustainability.

Implementation Framework

6. InDEA 2.0 – Implementation Framework

InDEA is about digital ecosystems – a concept which is still evolving. There are no standard methods and frameworks for implementation. Some of the current trends which are promising have been discussed in the previous chapter. This chapter provides guidelines on implementation, based on the experiences of practitioners who implemented comparable projects in this space in the last few years.

6.1 Enable Vs Build

InDEA tries to address the needs of large and complex digital ecosystems as they evolve. These needs may not be precisely articulated in the early stages but are discovered or evolve over a period. Hence the traditional way of systems development by the government either by themselves or through outsourcing may not work perfectly or efficiently. Digital ecosystems require implementation frameworks that are non-traditional and provide substantial degrees of freedom to the private sector to 'build' the ecosystem organically over a period. However, for this to happen, the Government needs to establish two types of enablers, namely, **policy enablers** and **technological enablers**. Establishing these enablers calls for special efforts, which can be made in a phased manner after this framework is formally notified after due process of consultation and approval.

Policy enablers include the following:

a. **Procurement Policy for digital ecosystems**: which should, inter alia, enable the following:
    i. Outcome-based procurement process
    ii. Outcome and SLA-linked terms of payment

    The procurement policy should be used sparingly in cases where Government must necessarily build certain core infrastructure or building blocks.

b. **PPP Framework**: a framework for public sector agencies to collaborate with the private sector to create innovative and scalable digital ecosystems that provide customer-centric services. The role of the public sector would be that of an enabler or facilitator and private sector plays the major role in the design and implementation. Public sector, for instance, can enable access to relevant data, use of its field machinery, and delivery systems, besides fast-tracking/ simplifying the licensing / statutory processes. The framework would enable selection of PPP projects and partners in a transparent ad accountable manner. It would ensure that the public and private sectors take up responsibilities which they are best positioned to perform.

c. **Data management and sharing policy**: Data is the oxygen of digital innovation. Providing access to the data available with the public sector to the private sector would spur innovation and value-added services in the G2C, G2B and B2C space. Organizations, both public and private alike, are reluctant to share the data collected by them with other organizations for several reasons. This would impede the evolution of digital ecosystem. To overcome this barrier, central and state

governments should come out with appropriate policies for managing data in public sector and sharing the same, with requisite safeguards, with those requiring the same for beneficial purposes. The governments can provide guidelines on what types / categories of data – historic data, master data, and transactional data - can be open, what kind of data needs specific permission/ privilege to access and how the departments can share data with other departments and the private sector. MeitY can develop model policies and guidelines in this regard to ensure uniformity and speed in adoption.

d. **Rules of Engagement**
A digital ecosystem comprises of several types of players both on the demand side and supply side, across the entire value chain. The pace of growth would not only be slow but also haphazard in the absence of a set of rules. It is like the condition of traffic, including traffic jams in the absence of the rules of the road and the traffic signals. The rules of engagement could be generic with some special provisions for each sector. The rules specify (i) how to get engaged with the public sector agencies for access to data (ii) the compliance requirements to be met (iii) the minimum required IT Infrastructure and safeguards on security, privacy (iv) trust (v) standards and protocols to be adopted and (vi) mechanisms for grievance redressal.
MeitY can develop model rules of engagement to ensure uniformity and speed in adoption.

Technology enablers include the following:

a. **Ecosystem sandbox**: The concept of Sandbox had its origins in relation to developing solutions in a highly regulated sector, like the financial sector. We have a few examples of Sandboxes in India set up by RBI, IRDA and NHA. It is desirable that every large digital ecosystem sets up its own 'ecosystem sandbox' to validate compliance of a solution with regulatory requirements but also technological requirements like interoperability, security and privacy besides commercial viability and scalability. A reference architecture for ecosystem sandbox may be designed to cut short the gestation period in establishing the sandbox in any sector.

b. **Data Exchange**: The basic concept on which the visionary idea of data economy is founded is the establishment of a data exchange(s) that enables the providers and consumes of data to discover each other and the data (available/ required), and to exchange the data with ease, transparency, and compliance. A high-level reference model of the Data Exchange is provided in **Annexure 4**. Ministries, States and the other ecosystem players can explore setting up data exchanges needed in various sector to accelerate the development of data economy, which is estimated to be of the order of US$ 500 billion in 2025. The **DEPA framework** designed by NITI Aayog may be leveraged in this regard.

c. **Gamechangers**: The example set by UPI gives credence to the belief that most of the sectors of the economy have the potential for discovery of technology gamechangers that are innovative, disruptive, impactful and pan-India. It is necessary for each sector to create appropriate incentives for the discovery of the

gamechangers. This can be an exciting opportunity that unfolds as a part of the development of architecture of a digital ecosystem in line with the principles of InDEA 2.0

d. **Operational guidelines** that 'enable':

   i. Open the development and staging environments for collaborative development by other members of the ecosystem
   ii. Expose application services through APIs so that ecosystem players may develop value-added services
   iii. Avoid re-inventing the wheel and try to reuse the applications/ components already operational.

6.2 Guidelines for architecting InDEA Digital Ecosystem for a sector/ State

Strictly speaking, digital ecosystems can't be *architected*. They evolve. However, it is desirable that the proponents create an aspirational picture of what the digital ecosystem should achieve and could visualize the same in the form of an architecture. The following is a possible path for such a visualization.

6.2.1 Developing Vision

Developing a vision of the digital ecosystem for the sector is a necessary first step. The stakeholders should be clear on what is the major challenge that is being addressed and the overarching benefit it would bring. The vision statement should be precise and picturize the state of the sector after 5 years. The sector policies of the Central/ State government together with the related SDGs shall be the basis of developing the vision of the digital ecosystem. The vision should reflect the future of the sector with widespread use of technologies emerging currently and be realistic at the same time, factoring the availability of resources.

6.2.2 Designing Blueprint

Creating a 'blueprint' should be the first major milestone in the InDEA journey. 'A business blueprint in all its essence is the genuine, realistic and conclusive detailing of our understanding of the scope, the specifications and the completeness of the solution design to be fulfilled to the business objectives, desired project outcomes and envisioned benefits'. For the purposes of InDEA, the term blueprint connotes a high-level document that deals with the following topics:

a. **Scope** of the architecture initiative
   This includes defining the objectives, principles, functional scope, stakeholder value proposition and measures of success. Unless the scope is reasonably bounded, such exercises can go on for a longtime and become infeasible. Prioritization of the components of the scope is an important step.
b. **Architecture** of the Digital Ecosystem
   One of the architecture patterns recommended by InDEA (in section 3 of this report) may be selected and suitably customized to fulfil the vision and achieve the objectives. The Architecture may be defined as a multi-layer structure and comprise of core, common and reference building blocks. The functionality of each building block may be defined at a high-level.

c. Standards

Standards are of two broad categories – domain standards and technical standards. While the digital architecture is basically concerned with the technical standards, it is necessary to consider the domain standards as well since an ecosystem can not evolve speedily in the absence of the domain standards that flow across the value chains of the sector.

An extensive list of technology standards has been provided in IndEA 1.0. These standards may be updated by MeitY annually and made available in inDEA Portal for the benefit of all the stakeholders.

d. Implementation Framework

An architecture can be as good as it is implemented. As alluded to earlier, Government can play the initial catalyzing role in the evolution of digital ecosystems. This involves essentially, setting up a Program Management Unit (PMU), establishing Architectural Governance structure, creating a core group drawn from the community for setting the vision and identifying the priorities and core building blocks, defining the specifications of the building blocks, selection of an implementing agency or consortium that creates all the enabling environment for the ecosystem to evolve.

An important aspect of the implementation framework is establishing an **institutional mechanism** for the implementation and sustenance of the initiative. The two obvious choices are to entrust the responsibility to one of the organizations of the ministry or the State that has all the required capabilities to handle the multiple tasks or to establish an SPV to undertake the program. These capabilities include technical, domain, legal, commercial and program management. In either case, the organization (a wing in an existing organization in the first option and the SPV in the second option) shall be autonomous in taking all architectural decisions, agile and have the necessary authority over the jurisdictions in which the initiative is to be implemented. The successful examples of SPVs are UIDAI (Aadhaar), NPCI (UPI) and GSTN (GST).

6.2.3 Consulting Stakeholders

The essence of the digital ecosystem is to allow it to be developed in a collaborative and consultative manner such that the outcomes are user-centric and need-based. The consultation can be done at multiple stages through methods such as publication of draft papers and designs inviting comments, conducting a series of workshops with the stakeholders like the States, industry, academia, and civil society organizations. Working Groups constituted for defining/ detailing the building blocks and for developing the specifications can all be represented significantly by experts drawn from these stakeholder groups. The vision itself should be developed consultatively by conducting a Vision Workshop involving key stakeholder groups. Involving the civil society organizations would not only bring in citizen-centric perspective but also ensure that the data protection and privacy aspects are adequately taken care of in the designs.

6.2.4 Adopting Agile Principles for Architecture Development

There is a perceptible debate on the merits of developing architecture in a structured way. Concepts such as Agile Manifesto and DevOps have questioned the need for architecture. To reconcile these apparently conflicting perspectives, MeitY has developed the Agile IndEA framework which recommends developing the architecture in multiple sprints. The principles and methods recommended in Agile IndEA framework are quite relevant to the implementation of InDEA 2.0 and may be read as part of this report.

6.2.5 Leveraging IndEA 1.0

Does InDEA 2.0 supersede IndEA (1.0)? No. Are the principles and methods suggested in the latter still relevant? Yes. The Agile IndEA framework addresses these issues. Stated briefly, (i) the principles of IndEA 1.0 have been adopted in the set of InDEA 2.0 principles. (ii) the technology standards recommended in IndEA 1.0 are relevant for firming up specifications, with the caveat that IndEA 1.0 needs to be updated with the latest standards and (iii) the reference models developed by IndEA 1.0 may be referred to while undertaking detailed design of system architectures.

6.3 Testing and Certification

It is necessary to introduce a degree of rigour in implementation/ adoption of InDEA 2.0 for all major IT initiatives in future. To this effect, Meity, GoI may formulate an appropriate scheme of testing and certification of projects for compliance with InDEA 2.0 principles, patterns, and other recommendations. An organization such as STQC may be entrusted with this responsibility. Multiple private firms may be empaneled for testing and certification to expedite the process of testing and certification.

The list of organizations complying with the InDEA 2.0 requirements may be publicized to incentivize adoption by others.

6.4 Leveraging Emerging Technologies

Emerging technologies like AI, ML, IoT and DLT are making inroads into several sectors of the economy in most of the IT-savvy countries, including India. Significant degree of innovation is happening basing on the emerging technologies. It is necessary to formulate a set of enabling policies to promote the growth of these technologies. The data policies should be designed with adequate enabling provisions so that innovators can access data with relative ease and in compliance with the applicable regulations.

From an architectural perspective, like that of InDEA 2.0, it is necessary that architectures should be so designed to ensure that the emerging technologies are mainstreamed into the architecture by design rather than being retro-fitted. Organizations embarking on greenfield IT projects should explore the feasibility and desirability of deploying emerging technologies for enhancing the value to stakeholders and to innovate.

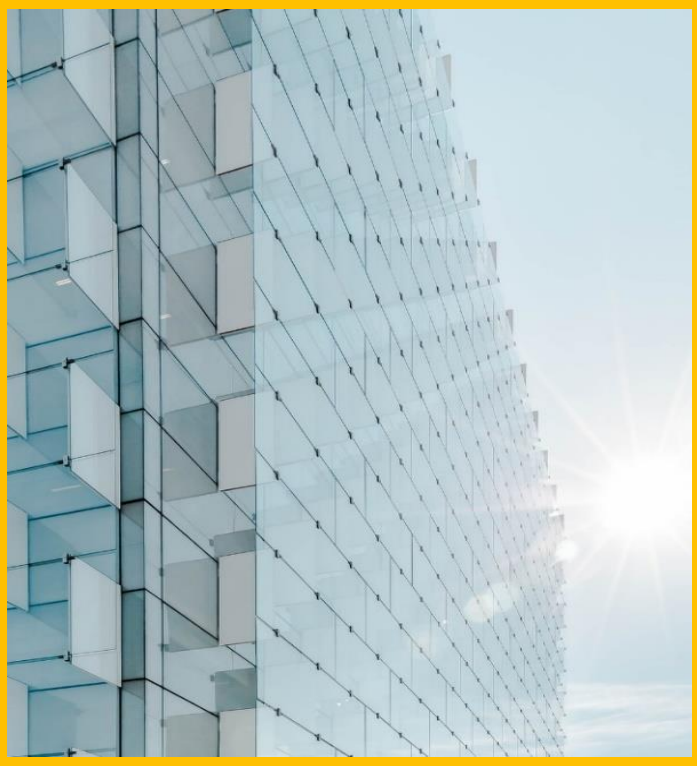
6.5 Architecture Governance

Adoption of InDEA is a medium and long term initiative. Sustainability over such a period is an important consideration. Besides this quality of InDEA implementations is a requisite for the program to proliferate and produce impact. All these requirements can be met only by establishing a robust governance structure for guiding the adoption of InDEA 2.0. The recommendations of IndEA 1.0 and Agile IndEA framework on Architecture Governance may be adopted in toto to achieve success.

6.6 Way Forward

Considering the medium and long-term benefits of widespread adoption of InDEA 2.0 across the country, both in the central government ministries and State Governments, it is recommended that Govt of India may formulae an appropriate central sector scheme of providing technical and financial assistance to the organizations adopting InDEA 2.0.

Building capacities for InDEA 2.0



7. InDEA 2.0 - Building capacities and promoting adoption

World over, when governments aim to introduce digital governance, the crucial factor is to build the capacity and competency of the key stakeholders of the change viz. the employees of the government sectors and the professionals from the public and private sector. The former group is responsible for conceptualizing the business value and the policy changes required to enable realization of such value. The latter would be responsible to design, develop and implement the program in a scalable way by adopting the right architectures, technologies, solutions and methods.

Capacity building assumes a special significant in the context of InDEA 2.0 for the following reasons:

- The concept of digital ecosystem is nascent and not much knowledge exists on it, even among management and technology professionals.
- InDEA 2.0 is a high-level framework, requiring significant detailing to be done in the context of any Ministry or State to create the right architecture and building blocks.
- Realizing interoperability across multiple layers of the ecosystem could be quite challenging, requiring significant change management in multiple organizations, public and private.
- Concepts like co-design and co-development, enablement rather than building are easier said than done.

7.1 From Capacity Building to Competency Building

InDEA2.0 relies crucially on a wide understanding and adoption of the principles of "Ecosystem Architecture" and "Federation" in architectural, infrastructural and implementation aspects of digital transformation. As a run up to IndEA2.0 program while we continue work on capacity building, we must raise the bar to competency building to realize the vision of InDEA 2.0 program.

Figure 6.1 shows the different levels of maturity of HR for implementing programs.

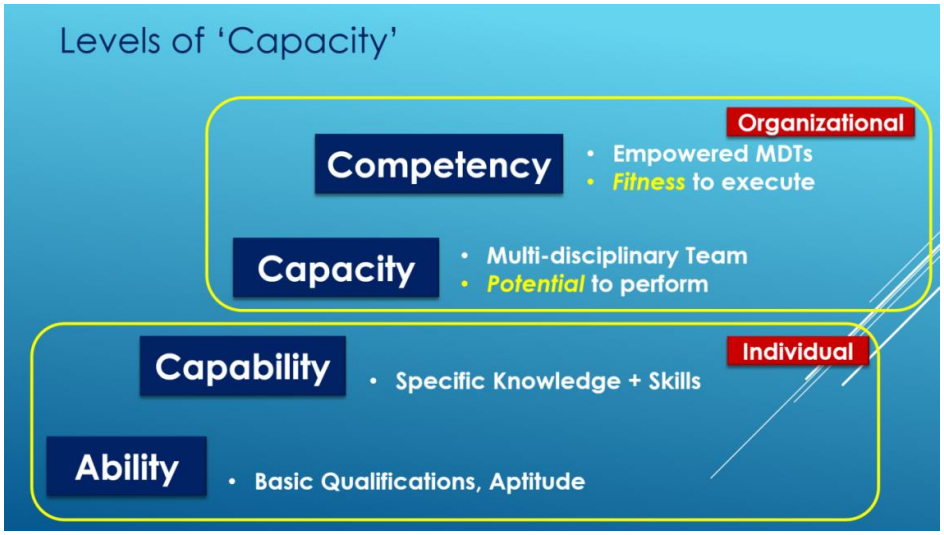


Figure 7.1: Capacities and competencies

As Figure 7.1 indicates, ability and capability are attributes of individuals while capacity and competency are attributes of organizations. While ***capacity*** indicates the ***potential*** to

perform, ***competency*** indicates the existence of empowered multi-disciplinary teams that have the fitness to ***execute*** large programs.

Executing the InDEA program is a gigantic and complex task especially given the organizational dynamics, complexity of the government sector and the diversities across the country. This requires a series of carefully designed plans to be undertaken widely amongst the target groups for graduating from "capacity building to competency building".

7.2 Target Groups

The proposed program aims to create capacities and competencies in organizations, both in public and private sectors, to understand, design, implement and proliferate InDEA 2.0. among broadly two target groups.

- Government staff.
- Professionals.

The following gives a rationale and composition for this categorization.

- The government staff are categorized under either Administrative or Policy streams. Typically, the targeted group from the government sector would be a hybrid group with the following functional profiles.
  - Top policy makers and administrators at Central and State Governments- Secretaries/Addl/Joint Secretaries to GOI;
  - Principal Secretaries to State Governments, Commissioners
  - Heads of Department of Central and State Governments.

- The professionals are categorized under either Architectural or Development streams. Typically, the targeted group from the public and private sector domains with the following functional profiles will be the targets.
  - CTO, COO, Architects, System Analysts, CISOs, Privacy Officers.

7.3 Themes for Capacity Building

The brief of the program with an abstract of the objectives of each of the training modules targeting capacity building are given below keeping the objectives and principles in focus and the pre-existing expertise of the targeted groups. The detailed program structure and syllabi are given in the **Annexure 6** titled "Training modules".

- The program would focus on administrative, techno-policy, infrastructural, design, development, architectural components and details of InDEA 2.0 program. This includes principles of digital governance, policy aspects of technology in digital/e-governance, skills in developing artifacts relating to digital governance projects falling under InDEA 2.0 program.

- The central theme of this program would be around the principles of Ecosystem Architecture in a Federated hierarchy with security/privacy principles in focus.

7.3.1 *Government Officials*

The following program structure is suggested for the senior government officials.

a. Foundation - Common Module for both Administrative and Policy streams

- **Abstract**

  The goal of this module is to provide an overview of digital governance, the overarching vision of Digital India Program and the principles of InDEA 2.0. Digital governance is often defined as the adoption and use of Information and Communication Technologies (ICT), in particular the internet, to transform the relationship between government and society in a positive manner. The major reform paradigm of digital governance is moving towards an entrepreneurial approach synchronizing with the functional hierarchy of the government. In case of IndEA2.0 this transforms to architectural approaches in a federated system with privacy and citizen-control in focus. The topics couls include the basics of (i) enterprise architecture and ecosystem architecture (ii) Data Governance (iii) Data Management (iv) Data Protection (v) Interoperability (vi) Principles of Federated Architecture (vii) Procurement and PPP for InDEA (viii) Capacity & Competency Building (ix) Business Vision and Business Architecture (x) Role of emerging technologies (xi) Concepts of Building Blocks and (xii) Architecture Governance.

b. Stream 1 – Administrative

- **Abstract**

  The goal of this module is to provide concepts that are crucial for IndEA2.0 laying the foundation for the importance of administrative aspects of EA in governance. The advanced concepts of technology are introduced in a gentle way. The module wraps up with focus on significance of factors like partnerships, co-design, stakeholder engagement, enablement as the preferred option compared to building, outcome-focus of InDEA2.0, basics of IndEA 1.0 and Agile IndEA framework.

c. Stream 2 – Policy

- **Abstract**

  The goal of this module is to provide deeper insights of InDEA2.0 laying the foundation for the importance of policies related to technology, especially data policies and PPP frameworks. They are crucial enablers to the success of InDEA 2.0. The advanced aspects of technology are introduced in a gentle way. The module wraps us with focus on significance of factors like privacy, AAA, security, provenance, performance, quality, capability, usability and availability for the success of InDEA 2.0

d. Case study and Discussion (Optional)

- **Abstract**

  The goal of this module is to discuss approaches towards adoption of InDEA 2.0 by comparing and contrasting the advances in India and in other countries. Real-life problems involving the concepts and principles of EA and digital ecosystems would be provided to all members to work upon. Both the groups (administrative and policy) would be divided into small teams and required to come up with ideas and solutions to the problems. Each group would present their learnings followed by a debate and QA.

7.3.2 Professional Stream

The following is program structure is suggested for the professionals.

a. Foundation – Common module 1 (For both architectural and technological streams)

- **Abstract**

  The goal of this module is to provide an overview of digital governance and InDEA 2.0- the overarching vision of Digital India Program. This module gives a heads up to both Architectural and Technology streams from the view point of digital governance. The following topics are suggested at an advanced level: (i) Detailed exposure to Enterprise Architecture Models (ii) Reference Models of IndEA 1.0 (iii) Principles of InDEA 2.0 (iv) Detailed exposure to federated architecture, federated data (v) Federated Digital ID (vi) Security & Privacy- by-design (vii) IndEA Architecture Development Methodology (viii) Case Studies of Aadhaar, GSTN, DIKSHA and NDHB (xi) Case studies of Emerging Technologies (x) Program Management.

b. Stream 1 – Architectural

- **Abstract**

  The goal of this module is to provide complete deep insights in to EA models (both generic and in governance), technology tools and trends. Crucial aspects of security and privacy by design are dealt in detail. The module wraps up with focus on components of EA, components that enable Federated models with a case study on IndEA and digital ecosystem.

- **Stream 2 – Systems**
- **Abstract**

  The goal of this module is to provide deep insights into technology and trends for EA from the point of view of a systems professional with focus on Data and Information, the framework for implementing programs with colossal cross sectorial, high velocity near real time data. The module wraps up with focus on infrastructure provisioning for Enterprise Federated Architecture in governance with crucial aspects like security, privacy, availability and performance in infrastructural provisioning.

7.3.3 IndEA2.0 Certificate Course

An appropriate 6-week online InDEA 2.0 Certificate Course is proposed to address the requirements of mid-level and operational level professionals in both public and private sectors.

This program would be open to any person/professional to attend and earn a certificate. Typically, the program will run on lines of popular MOOCs programs. It is also proposed that this program can be accredited to one of the popular MOOCS programs, after it gets stabilized in due course of time.

The detailed course contents will be based on targeted outcome of the InDEA 2.0 Certificate course.

The following broad framework is envisaged.

- Purpose and process-oriented approach
- Subject matter and Domain Experts to be leveraged as faculty
- Multiple delivery channels for imparting training leading to certification.

The certification will be broadly based on knowledge, skills and abilities in

- Concepts of Digital governance
- Enterprise /Federated Architectures
- Technology and Adoption
- Devising implementation and adoption plans
- Regulatory aspects
- Standards compliance
- Data Analytics
- Quality and Performance Metrics
- Security, Privacy, Provenance
- Emerging technologies like AI, Block Chain
- Program management
- India-specific Digital governance programs and frameworks.
- A mini project with a specific practical problem statement.

7.4 Delivery Channels

Technology-enhanced training is preferred by organizations since all records and training material can be digitized and stored at a central location preferably on cloud-based storage systems. This allows delivery of relevant training and development material to reach a wider audience and accessible from the device of choice. Such training scenarios and approaches through proper delivery channels ensure getting optimum utilization of human resources yielding better Return on investment (ROI).

Learning is always augmented with new methods to deliver training material personalized to the scenarios of the domain in which the trainees are working.

The need for hybrid delivery mechanisms is emphasized. An appropriate mix of F2F mode, virtual CB, self-paced learning and workshop mode is proposed.

- **Face to Face**
  - On-site : one faculty per 15 candidates.
  - 2 days for basic and 5 days for advanced programs.
- **Virtual CB**
  - Online programs with fixed program schedule followed by standard certification in IndEAD2.0 as defined before.
- **Self-paced learning**
  - Online and offline programs followed by standard certification in IndEA2.0 based on adopted pace of the candidate.
- **Workshop mode**
  - On-site : one faculty per 15 candidates
  - Group discussions on topics related to InDEA 2.0
  - Simple rapid evaluation methods and metrics
  - Certification of participation in InDEA 2.0 workshop.

7.5 Content creation and dissemination

Current methodologies include content that can be in the form of video, documents, multimedia enriched slides or mobile apps.

Choosing proper methods for creation of content enhances its value. This includes crowd sourcing and curation, commissioning development of case studies by academic and research institutions.

Considering the broad nature of the process of content creation and dissemination the following methods are proposed

- Detailed documentation, case studies and instruction/training creation based on India specific Digital governance programs – *Academic institutes, Government and Service providers can be pooled in to create the contents*
- Subject Matter Experts (SME) to create rich contents on SOA (State of Art), Trends and Standards.
- Academic and research institutes on Emerging technologies and Indigenous adoption – to give inputs for creating course contents and lecture materials.
- Interviews of successful practitioners / administrators of large enterprise digital transformation projects
- All lectures and training to be created and handled by either Subject Matter Experts (SMEs) or certified professionals.

7.6 Competency Maturity Model

The Capability Maturity Model (CMM) is widely adopted development model based on defined "maturity" levels of the capability of an organization or institution. The Software Engineering Institute (SEI) adopted the CMM model to procedures and framework used to develop and refine an organization's software development process. This defines a five-level evolutionary stage of increasingly organized and consistently more mature processes. A similar but highly abridged approach is envisaged for measuring maturity in InDEA 2.0 capacity and competency building.

The above model can be widely and efficiently adopted based on a robust institutional framework. This plan should include procedures, formal/informal conventions, customs and norms to evaluate the maturity level and the typical candidates for the same.

This framework can be in the form of exhibited proficiency and role played in adoption, proliferation and knowledge imparting on/of InDEA 2.0.

The same is presented in the Table **6.1**.

Maturity Levels	Scope and Indicators of Maturity level	Typical Candidates
Visionaries (Level 5)	*Forward Integration,* *GOI advisory* *Legislation and Governance* *GOI Task force participation*	State Actors, Non-State actors and Academia matured from Level 3 or Level 4.
Adapters and Managerial expertise (Level 4)	*Of Processes and policies across multiple sectoral and cross sectoral adoption of IndEA2.0*	State Actors as adapters and implementers matured from Level 1 Non state actors as consultants matured from Level 2 or Level 3
Sectorial Expertise (Level 3)	*IndEA2.0 Processes, policies adaption implementation and knowledge imparting in specific*	State Actors as adaptors and implementers matured from Level 1 and Non State Actors as

	public sectors.	consultants matured from Level 2 or Level 1
Domain Expertise (Level 2)	*Exhibited and professional expertise in adapting and/or knowledge imparting of IndEA2.0 framework, Administrative Policy, Architectural and technology components*	State Actors matured from Level 1 , Non State Actors as Consultants matured from either Level 1 or expertise from experience and working knowledge
Fundamental (Level 1)	*IndEA2.0 certification (6 weeks course) or* *The targeted group program for IndEA2.0*	State Actors, Non State Actors, Corporate, Public Academia

7.7 Recommendations on institutional arrangements

Following are guidelines on the institutional arrangements to impart InDEA2.0 skills through training and certification programs on a viable and sustained basis.

- Identified Academic institutes may act as nodes for InDEA 2.0 certification program.
- InDEA 2.0 (theory + practical) optional course at BSC / MSC/ BE IT streams with a mini project.
- Candidates selected for AIS and Central Services to undergo a mandatory InDEA 2.0 training program at Fundamental level (Level 1)
- Training Institutes (with InDEA 2.0 certified experts) may provide institutional collaboration for imparting training to private sector professionals.
- Public sector employees working at mid-management level and above to a mandatory fundamental level InDEA2.0 training (by any delivery channel) and get certified

GLOSSARY

Building Blocks	A package of self-contained functionalities defined to meet business needs through a set of services made available via APIs and optionally via reference solutions. Building blocks have to interoperate with other building blocks within the same system or across systems.
Directories	Directories are public listing of various master data and codes in machine representable and API accessible way. Since data listed in directories have no link to any person, entity, or things (controlled in person/entity), directories are considered part of open data (master data) and do not require any consent mechanisms and access restrictions.
Digital Ecosystem	A digital ecosystem is a distributed, open socio-technical system with properties of self-organisation, evolution, scalability and sustainability inspired from natural ecosystems connected by a shared Vision and a set of shared digital platforms. An ecosystem may comprise organizations, developers, service providers, people, data, processes and things.
Federated	Distributed and decentralised systems to preserve autonomy and agency of States, departments organisations and institutions. These systems must be interoperable through common standards and specifications, while maintaining their independence.
Registries	An entity data sets belonging to ecosystem stakeholders and actors which must be designed for consent-based access and reusability by other building blocks. These registries can be maintained in a single source at appropriate level (National or State) in digital form (machine-readable) and made available via APIs for other blocks and applications to use.
Master Code	A pre-assigned codes to data elements, so that the data entered into a system can be reliably read, sorted, indexed, retrieved, communicated and shared between systems. These master codes must be maintained in a single source at the central level in digital form (machine-readable) and made available via APIs for other blocks and applications to use.
Interoperable	For systems to be able to connect with each other on a need-basis through open specifications and APIs. This includes interoperability (based on appropriate rules, administrative and legal frameworks) across systems and domains such as health, child development, social justice, juvenile welfare, tribal welfare and others.

ANNEXURES

Annexure 1: Executive Summary of InDEA 1.0, within the Reference Models

IndEA Overview

The Context of IndEA

The e-Governance initiatives in India have acquired a new momentum with the launch of the Digital India program by the Central Government. The thrust given to Aadhaar and the emphasis on its adoption in the various welfare schemes have created the expediency for painting the big picture of e-Governance so as to derive the maximum out of this soft infrastructure. The need for adopting a holistic approach in the domain of e-Governance has become evident from the interoperability issues within and across the multiple clusters of stand-alone applications developed by the States and Central Ministries over the last decade. Against this background, the Working Group constituted by the Central Government came up with a holistic framework, named **IndEA**, for streamlining, standardizing, and optimizing the e-Governance efforts across the country so as to address the much-needed interoperability and integration.

IndEA defined

IndEA, a catchy acronym for the **India Enterprise Architecture**, is a framework for developing a holistic architecture treating the Government as a single enterprise or more realistically, as an **Enterprise of Enterprises**, which are functionally inter-related. IndEA is a structured combination of several Reference Models that, together, enable a **boundary-less flow of information** across the length and breadth of the government and facilitate the delivery of **integrated services** to the stakeholders, namely, the citizens, businesses and employees. Strictly speaking, IndEA is not an Enterprise Architecture as its name seems to connote. It is a comprehensive and convenient *framework* for developing Enterprise Architecture to support ICT enabled transformation across governments. It is an authoritative reference providing an integrated, consistent and cohesive view of strategic goals, business services and enabling technologies across the entire organization. IndEA can be adopted and used successfully, by the Central, State and Local Governments alike, irrespective of their size and current status of technology implementation. It can also be used by PSUs, large departments and agencies of the Government to derive the envisaged benefits.

Simply stated, IndEA is a way to establish **Unity in Diversity** in the domain of e-Governance. It is a framework that enables the development and implementation of Enterprise Architectures independently and in parallel by all governments and their agencies across India, conforming to the same models and standards.

Vision & Value Proposition of IndEA

The Vision of IndEA is "***to establish best-in-class architectural governance, processes and practices with optimal utilization of ICT infrastructure and applications to offer ONE Government experience to the citizens and businesses***".

IndEA brings to the table the entire value proposition of adopting Enterprise Architecture plus more. It derives its approach from the globally known architectural frameworks like the TOGAF, Zachman and the Federal Enterprise Architecture. The models and concepts contained in these global frameworks have been substantially simplified and suitably contextualized to the Indian conditions. The principles of 'Just-in-Time' and 'Just Enough' have been advocated in the design and implementation of Enterprise Architecture.

The major benefits envisaged by the adoption of IndEA framework are:

1. Provide a **ONE Government Experience** to the citizens and businesses, by offering integrated services through multiple channels, in a contactless, frictionless manner.
2. Enhance the **efficiency** of delivery of services, by defining and enforcing service levels of a very high order
3. Improve the **effectiveness** of implementation of the developmental and welfare schemes through a holistic performance management.
4. Enhance the **productivity** of employees and agencies through easy access to information.
5. Provide integrated and cross-cutting services through seamless **interoperability** across the Whole-of Government.
6. Bring in **flexibility** and **agility** in making changes to the systems to align with the best practices and to leverage the latest technologies.
7. Realize **cost-effectiveness** through use of shared infrastructure and services.
8. Enable establishing a Connected Government that works for **inclusive development**.
9. Maintain the right balance between **security** of data and **privacy** of personal information.

Architectural Patterns Adopted by the Working Group

It is significant to mention the following major strategies adopted by the Working Group:

1. IndEA Framework is basically designed keeping the **architectural needs of the State Governments**. However, the Models are developed in a sufficiently generic manner, adopting standard notations, such that the Framework can be adopted by the Ministries of the Central Government and the CPSU's in the upper tier and the Local Governments in the lower tier.
2. Federated Architectural Pattern is chosen for IndEA framework for better administrative feasibility, need for decentralization of implementations, on-boarding of legacy/ ongoing efforts of e-Governance and above all, the need for state governments to have the flexibility to build state specific ICT services. The Core Platform is the backbone to provide ONE Government Experience and interoperability. Any Government or agency delivering ICT services should centrally deploy the Core Platform. In this sense, **IndEA Framework adopts a hybrid architectural pattern** – a combination of centralization of core and common assets and decentralization of domain platforms.

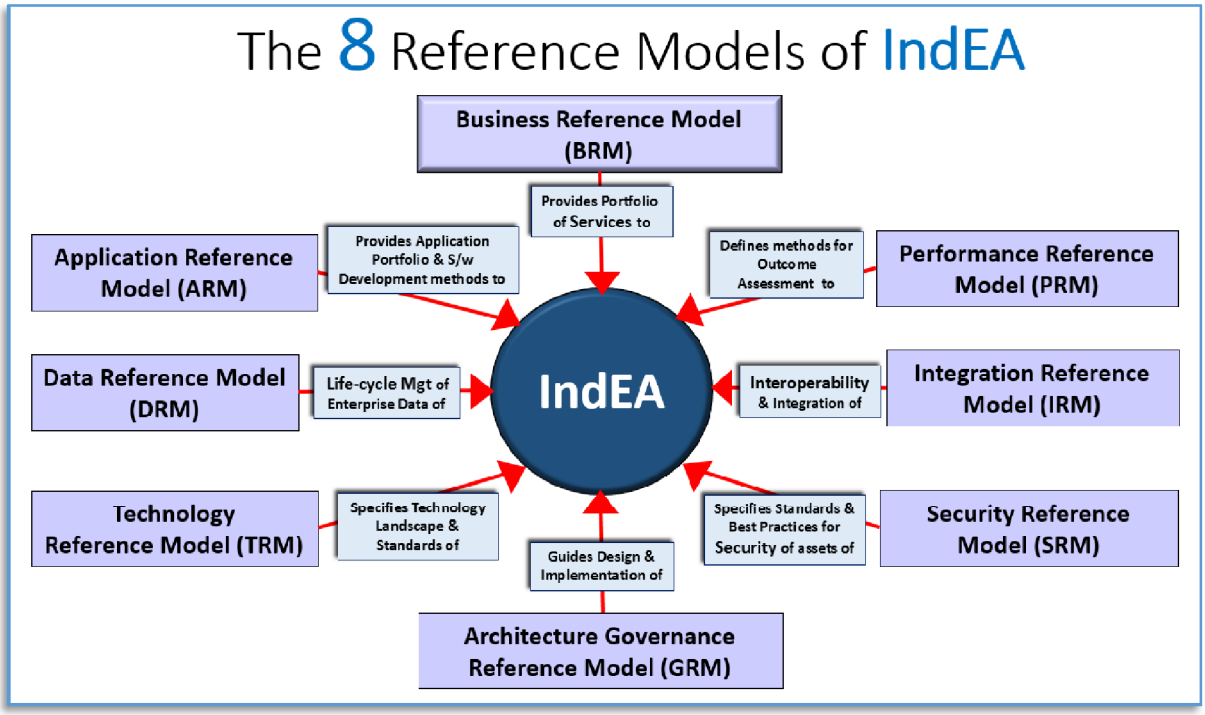
Structure of IndEA

In line with other globally known architectural frameworks, the structure of IndEA consists of a number of Reference Models, each dealing with a specific domain of the Enterprise Architecture. **A Reference Model is an abstract representation of the entities relevant to a domain of the Enterprise Architecture, the inter-relationships among those and the standards to be followed.** The representation is both **graphical** - adopting standard notation like the **UML**, and **descriptive** -

specifying the capabilities of each of the components (entities) comprising the Reference Model. Each Reference Model also contains the list of standards that should govern the entities, their relationships and the manner of communications between them. All the Reference Models comprising IndEA are technology-agnostic. These Reference Models are, by definition, devoid of the details specific to their implementation. The Performance, Business, Data, Application and Technology Reference Models using UML notations are depicted in the **Annexure (X)** – Reference Models in UML Notation.

Through a combination of the above-stated 3 basic attributes of all the Reference Models, namely, **abstraction, standards-base and technology-neutrality**, the IndEA framework is sufficiently generic for its widespread adoption by various entities of Government from national to state to local authorities and organizations.

IndEA framework comprises of 8 Reference Models, represented graphically below, viz., **Business,**



Application, Data, Technology, Performance, Security, Integration and Architecture Governance.

Principles of IndEA

An Enterprise Architecture is to be founded on a set of **Principles** that inform and guide the Architecture Development process. A good set of Principles should satisfy five criteria, namely, **Understandable, Robust, Complete, Consistent and Stable**.

Citizen-centricity, Outcome-focus, Standardization, **Reusability** and **Integration** are the key *mantras* followed while designing IndEA. While individual sets of principles have been stated and explained in the respective Chapters relating to the 8 Reference Models, the most important of these principles are given below.

1. **SDG Linkage**: Performance Measurement Systems and associated metrics are aligned to Sustainable Development Goals prioritized by the Government.
2. **Integrated Services**: Integrated Services that cut across agency-silos are identified, designed and delivered through multiple delivery channels, to realize the vision of ONE Government.
3. **Sharing & Reusability**: All commonly required Applications are abstracted to be built once and deployed across the Whole-of-Government through reuse and sharing. Sharing & Reusability shall be subject to conformance with the principles of Security & Privacy.
4. **Technology Independence**: Application Design is open standards-based and technology-independent.
5. **Data-sharing**: Data is shared across the Government, subject to rights and privileges, so as to prevent development and use of duplicative sets of data by different agencies. Data Sharing shall be subject to conformance with the principles of Security & Privacy.
6. **Cloud First**: Cloud infrastructure is chosen by default for deployment of applications and on-site option is resorted to only with strong justification.
7. **Mobile First**: Mobile channels are mandatory for delivery of all services, among all delivery channels.
8. **Federated Orchestration**: Integration services, capabilities and orchestration processes are federated.
9. **Primacy of Principles**: The principles specified in this framework govern all reference models and their implementations.

Eight Reference Models of IndEA

An overview of the 8 Reference Models of IndEA is given below:

Performance Reference Model (PRM)

The key objective of PRM is to provide a uniform and consistent mechanism to measure the efficiency and effectiveness of the different sectors or domains in achieving the overall goals of the Government. The principal instrument of the PRM is a set of KPIs designed rationally to measure the outputs and outcomes of the various programs, schemes, projects and activities. A prioritized and phased approach for implementation of PRM is recommended so as to avoid the situation of creating a plethora of KPIs, which hide the actual performance and outcomes.

Business Reference Model (BRM)

The BRM is pivotal for the design of a good Enterprise Architecture, in so far as it looks at **purely** the business vision and the functions/ services required to fulfil that vision **but not** the technologies required to be used. The key entity in BRM is **Service**, be it customer-facing or internal. The watchwords of BRM are – Service Portfolio, Citizen/Business-centricity, Service Prioritization and Integration. A successful implementation of BRM requires a fundamental re-engineering of the Business Processes, elimination of non-value-adds and above all, identification of services that are common across the Government or across groups of departments and abstracting them to a combination of **uniform** processes and workflows.

With a view to give a concrete shape to the BRM, the Group attempted an identification of the **16 vertical domains** and **12 horizontal functions**, which, together, represent most of what a Government does.

An aspirational goal of IndEA is to support the concept of '**ONE Government'** with a single interface offered to the citizens, hiding the boundaries of government agencies. It necessarily involves the breaking of the departmental silos. Since it is not practically feasible to break the silos physically, this laudable objective is sought to be achieved by breaking them virtually, through the new concept of **Virtualization of Departments**.

Application Reference Model (ARM)

The Application Reference Model provides the foundation to automate *Services*, identified as a part of the Business Reference Model. It enables government to achieve its objective through collaboration and data-sharing between & within departments thereby providing effective business services to its stakeholders.

ARM provides a framework for grouping similar applications to maximize re-use. To this end, a **concentric set of layers represent the ARM Meta-model** within IndEA. The inner-most layer **of ARM** is the **Core Platform**, which provides the most generic services in a **domain-agnostic, application-agnostic and technology-agnostic** manner. The three layers around the IndEA Core relate to **Common Applications**, **Group Applications** and **Domain-specific Applications**.

ARM also captures guidelines and recommendations on Application Architecture Standards, use of Open APIs, **Microservices Architecture** and **Open Source Software**. It also specifies the **Secure Coding Standards** for Application Development.

Data Reference Model (DRM)

DRM provides the structure and description of the department's data (metadata), the logical data model (depicting the relationship between various data elements), taxonomy, the security associated with each data element and its sharing. It provides the framework to design the 3 components of Data Architecture, namely, **Data Description, Data Context and Data Sharing**. These 3 areas deal with Discovery, Creation, Management and Exchange of enterprise data. **Database Schema, Data Steward and Exchange Package** are the key concepts/ components in the 3 areas respectively. Defining **Metadata** and **Data Standards** are key activities in the design of Enterprise Data Architecture.

Technology Reference Model (TRM)

TRM depicts the **layout of the technology foundation** of ICT-based systems to be designed for delivery of identified business services. **TRM lists all the components** of the technology system on an end-to-end basis, including IT Infrastructure, Applications, Access Devices, Communication Systems and Service Delivery modes. TRM also **defines the currently applicable open standards** for all the solution building blocks and components and **identifies the Open Source Products** for each technology component.

TRM also deals with the various considerations for designing the solution architecture besides the options for application deployment and service delivery. Important among these are insourcing or outsourcing strategy, **cloud strategy**, and the **mobile strategy**.

Integration Reference Model (IRM)

Integration of Governmental Business processes and services across the breadth of the enterprise is needed for delivering the services conveniently to the citizens on a sustainable basis. Government entities need to organize, secure, prioritize, classify, and publish the information needed by other

entities for seamless interoperability. IRM consists of 6-layers of integration, namely, Performance, Process, Service, Application, Data and Infrastructure.

The objective of the IRM is to identify **all the technology options for integration** and provide guidelines and recommendations for integrating business applications, services, information systems and platforms for a **boundary-less information flow**.

Given the accent of IndEA on providing ONE Government experience to the users, the Integration Architecture assumes special importance.

Security Reference Model (SRM)

The SRM delineates the overall framework for providing information security to the entire gamut of IT systems in the enterprise. Integrity, privacy, confidentiality, and availability of information / IT systems are the key concerns addressed by SRM.

SRM adopts a layered approach to identifying and meeting the information security needs of the enterprise. The model identifies the security controls to be applied at **6 layers**, namely, the **Business Layer, Data Layer, Application Layer, Perimeter Layer, Network Layer and the End Point Layer**. SRM also touches upon the manner of designing **Security Policies** and **Standard Operating Procedures**.

Enterprise Architecture Governance Reference Model (GRM)

The objective of GRM is to manage and maintain architecture requirements and artefacts. It comprises of enterprise structure, processes and standards to ensure that the architecture is consistent with the business vision and objectives of the enterprise. Effective and efficient EA Governance ensures that priorities are based on broad consensus across the enterprise. EA is a continuous activity and governance is an integral part for its successful implementation and maintenance.

IndEA framework recommends a **3-tier governance structure**, namely, at the **political, executive and technology** levels.

The framework further recommends the establishing of 2 entities with distinct roles and responsibilities namely, Architecture Governance Board and IT Governance Board. Blurring or overlap of these two roles is likely to create conflicts and delays.

EA Program has to be governed keeping in view the triple constraints, namely, Scope, Time and Cost, which represent the 3 sides of a Project (Program) Management triangle. One side can't be changed without affecting the other. A brief treatment of the implications of Scope, Time and Cost has been given as a part of GRM.

Needless to say, an effective EA Governance system is critical to the success of IndEA.

Implementation Framework

IndEA is a framework for developing full-scale Enterprise Architecture for Governments. The 8 Reference Models comprising it need to be converted into respective sets of Architecture Artefacts so as to derive the maximum benefits out of IndEA. Such a conversion of RMs into Enterprise Architecture Artefacts involves Government-specific and/ or domain specific details to be worked on. **IndEA Adoption Guide** describes the methodology to be adopted for using IndEA to develop Enterprise Architectures.

At the whole-of-government level, an Architecture team shall maintain the IndEA framework by continuously evolving reference models through the transformation journey. Thereby, IndEA is kept relevant and as a means of identifying new common capabilities.

It is to be emphasized that developing and implementing the Enterprise Architecture is a medium-term exercise that can spread typically over **3 to 5 years**, depending upon the size of the enterprise and the availability of resources.

Annexure 2 :
Indicative set of principles of governance of Federated Architecture

1. Federated Architecture
   (FA) operates collaboratively, where governance is divided between a central authority and constituent units, balancing organizational autonomy with enterprise needs
2. The Central Authority's architecture can focus on the dynamics of economies of scale, standards, interoperability and the common requirements, while the constituent units' (States and organizations) architectures have the flexibility to pursue autonomous strategies and independent processes
3. Participating members can jointly agree upon the common goals and governance of the federation which is expressed by the policies governing the roles and responsibilities of membership, resource discovery, and resource access.
4. There is an administration role whereby federation membership, resource discovery, and resesource access can be granted or revoked according to governance policy
5. States and organizations can participate in a federation by selectively making some of their resources discoverable and accessible by other federation members
6. While the purpose of a federation is to collaborate and share resources, resource owners retain ultimate control over their own resources
7. The design of all the systems in the federation shall conform to the prevalent laws and regulations relating to security, privacy and data-sharing.

Annexure 3 : Case studies of GSTN, DIKSHA, NDHB

Case Study- GSTN

1. Executive Summary

The GST System Project is a unique and complex IT initiative as it established for the first time a uniform interface for the taxpayer under indirect taxes through a common and shared IT infrastructure between the Centre and States. The Centre and State indirect tax administrations which used to work under different laws, regulations, procedures and formats and consequently the IT systems worked as independent sites, were integrated into one system with uniform formats and interfaces for taxpayers and other external stakeholders.

A centralized approach to bringing a complex tax system to a single point interface with stakeholders, has resulted in optimum utilization of system and human resources as well. The availability of granular data on invoice and HSN has proved to be a big tool for improving compliance. This data for the whole country available at one place is also being used for policy purposes apart from increasing compliance.

As organization of information and digitization of applications bought suitable amount of transparency in business processes, it automatically resulted in increased efficiency in transactions between stakeholders. The introduction of GST has effectively reduced the information asymmetry which in turn resulted in significant reduction in transaction cost across eco-system. With advent of new technology, GSTN fosters a strong IT Infrastructure and Service back bone which further enables capture, processing and exchange of information amongst the stakeholders (including taxpayers, States and Central Governments, Accounting Offices, Banks and RBI.

2. Project Overview / history of project/ need

The matter relating to putting in place a strong IT Infrastructure and Service back bone which enabled capture, processing and exchange of information amongst the stakeholders (including tax payers, States and Central Governments, Accounting Offices, Banks and RBI) was discussed in the 4th meeting of 2010 of the Empowered Committee of State Finance Ministers (EC) held on 21/7/2010. In the said meeting the EC approved creation of an '**Empowered Group on IT Infrastructure for GST' (EG)** under the chairmanship of Dr Nandan Nilekani along with five state commissioners of Trade Taxes.

The Group was mandated to suggest, inter alia, the modalities for setting up a National Information Utility (NIU/ SPV) for implementing the **Common Portal to be called GST Network (GSTN)** and recommend the structure and terms of reference for the NIU/ SPV, detailed implementation strategy and the road map for its creation in addition to other items like training, outreach, etc. Prior to this, the Union Ministry of Finance had set up the Technical Advisory Group for Unique Projects (TAGUP) in March 2010 to make recommendations on the roadmap to roll out five major financial projects including GST.

The EG held seven meetings between 2nd august 2010 and 8th August 2011 to discuss the modalities.

After due deliberations, the EG recommended creation of a Special Purpose Vehicle for implementing the GST System Project. To enable efficient and reliable provision of services in a demanding environment, the EG recommended a non- Government structure for the GSTN SPV with Government equity of 49% (Centre – 24.5% and States – 24.5%) after considering key parameters such as independence of management, strategic control of Government, flexibility in organizational structure, agility in decision making and ability to hire and retain competent human resources. The shareholding pattern would ensure that the Centre individually and States collectively are the largest stakeholders at 24.5% each. In combination, the Government shareholding at 49% would far exceed that of any single private institution.

The Government of India approved the proposal for setting up a **Special Purpose Vehicle to be called Goods and Services Tax Network** on the lines mentioned above on 12th April 2012. Following decisions were taken in this context:

1. Suitable and willing non-government institutions would be identified and firmed up by the Ministry of Finance to invest in GSTN-SPV prior to its incorporation.
2. The strategic control of the Government over the SPV would be ensured through measures such as composition of the Board, mechanisms of Special Resolution and Shareholders Agreement, induction of Government officers on deputation, and agreements between GSTN SPV and Governments.
3. The Board of Directors of GSTN SPV would comprise 14 Directors with 3 Directors from the Centre, 3 from the States, a Chairman of the Board of Directors appointed through a joint approval mechanism of Centre and States, 3 Directors from private equity stake holders, 3 independent Directors who would be persons of eminence and a CEO of the GSTN SPV selected through an open selection process.
4. Relaxation in relevant rules would be granted to enable deputation of Government officers to the GSTN SPV for exercise of strategic control and for bringing in necessary domain expertise.
5. GSTN SPV would have a self- sustaining revenue model, where it would be able to levy user charges on the taxpayers and the tax authorities availing services.
6. GSTN SPV would be the exclusive national agency responsible for delivering integrated indirect Tax related services involving multiple tax authorities. Accordingly, any other service provider seeking to deliver similar integrated services would be required to enter into a formal arrangement with GSTN SPV for the services.
7. GSTN would be funded through a one- time non- recurring Grant- in aid of Rs. 315 crore from the Central Government towards expenditure for the initial setting up and functioning of the SPV for a three year period after incorporation.

Objective-

On 1st of July, 2017, GST brought together multiple tax regimes administered by various tax authorities, including central and 36 states and union territories and to supplement this revolutionary reform, Goods and Services Tax Network (GSTN) has built Indirect Taxation platform to help taxpayers in India to prepare, file returns, make payments of indirect tax liabilities and do other compliances. GSTN operates primarily with the following objectives-

- Provide common and shared IT infrastructure and services to the Central and State Governments, Tax Payers and other stakeholders for implementation of the Goods & Services Tax (GST).
- Provide common Registration, Return and Payment services to the Tax payers.
- Partner with other agencies for creating an efficient and user-friendly GST Eco-system.
- Encourage and collaborate with GST Suvidha Providers (GSPs) to roll out GST Applications for providing simplified services to the stakeholders.
- Carry out research, study best practises and provide Training and Consultancy to the Tax authorities and other stakeholders.
- Provide efficient Backend Services to the Tax Departments of the Central and State Governments on request.
- Develop Tax Payer Profiling Utility (TPU) for Central and State Tax Administration.
- Assist Tax authorities in improving Tax compliance and transparency of Tax Administration system.
- Deliver any other services of relevance to the Central and State Governments and other stakeholders on request.
-

3. Implementation Methodology

Principles

GSTN was setup to ameliorate Efficiency, Transparency, Commitment, Collaboration, Excellence, Accountability & Innovation in the finance sector of our nation. Its vision is to become a trusted **National Information Utility (NIU)** which provides reliable, efficient and robust IT Backbone for the smooth functioning of the Goods & Services Tax regimen enabling economic agents to leverage the entire nation as One Market with minimal Indirect Tax compliance cost.

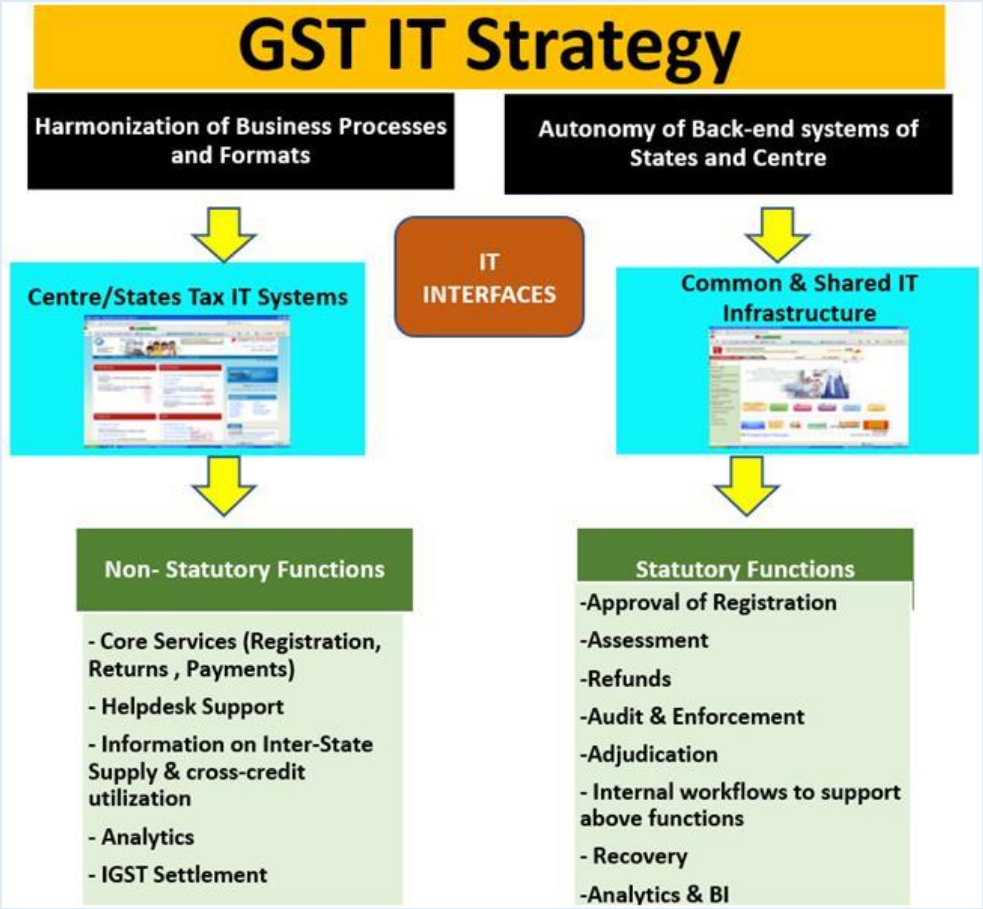
Infrastructure

GST Network was registered as a non-government, not-for-profit, private limited company under section 25 of the Companies Act 1956 with the following equity structure-

Central Government	24.5%
State Governments & EC	24.5%
HDFC	10%
HDFC Bank	10%
ICICI Bank	10%
NSE Strategic Investment Co	10%
LIC Housing Finance Ltd	11%

The decision to structure GSTN in its current form was taken after approval of the Empowered Committee of State Finance Ministers and the Union Government after due deliberations over a long period of time.

As per decision of GST Council, the shares held by non-Government Financial Institutions are being transferred to Central and State Governments so that both hold 50% shares each of GSTN and it becomes a 100% government owned company.



Capabilities-

The complexity of indirect tax reform, that is GST, required a dependable, scalable and highly secure system to serve all stakeholders involved in administering and enforcing GST law and applicable rules. GST System is a single face to all taxpayers for all statutory activities, such as payment of taxes, registering for new businesses, filing of returns etc.

The use of open source technologies and platform design philosophy, enabled GST System to merge tax systems of 36 states/UTs and CBIC into a single system, handle traffic of 1.3 Cr taxpayers, & operate without tight integration within GST modules, external entities, technology verticals and platform. The choice of technology principles, tools and architecture also provide for highly available fault tolerant (HAFT) system ensuring failure proofing. Projects of GSTN are-

1. **Goods and Service Tax (GST)** is the largest indirect tax reform in the history of India. The reform mandated integration of entire nation's diverse tax portfolio into a single taxation system. This brought upon a massive complexity in developing an IT platform, to handle not

only the diverse tax systems of 36 States/Union Territories & Union Government, but also needed providing a single interface for more than a crore taxpayers' for their GST compliance functions. GSTN has already enabled Tax Payment of 30.42 Lakh Crores by 1.25cr Taxpayers in India.

2. **EWay Bill** is an Electronic Way bill for movement of goods to be generated on the eWay Bill Portal. A GST registered person cannot transport goods in a vehicle whose value exceeds Rs. 50,000 (Single Invoice/bill/delivery challan) without an e-way bill that is generated on ewaybillgst.gov.in. GSTN has already enabled creation of over 165 Cr. E-Way Bills so far.

3. **E-Invoice** known as 'Electronic invoicing' is a system in which all B2B invoices are electronically uploaded and authenticated by the designated portal. Post successful authentication, a unique Invoice Reference Number (IRN) is generated for each invoice by IRP. Along with IRN, each invoice is digitally signed and added with QR code. This process is collectively called as e-invoicing under GST. Over 1129 Cr. B2B Invoices have already been generated over GSTN up till Dec,2020.

4. **TINXSYS** is a centralized system facilitating information exchange among CTDs of all States/Union Territories for better administration of inter-state trade of non-GST Goods. TINXSYS is the repository of information pertaining to dealers in various States registered under the Central Sales Tax Act. There have been 17.33 Cr. Payment Transactions & 60.78 Cr. Returns over the platform so far.

Future roadmap/sustainability-

As of now, GSTN is continuously improving taxpayer interaction with GST Portal with focus to ensure availability of all GST Services to Indian taxpayers and authorities in a seamless manner. Currently emphasis is on making the system more robust in terms of handling load beyond 1.5 Cr taxpayers, ensuring application durability and improving in-site navigation to ensure better user experience.

GSTN is also enhancing its offline tools to provide more freedom at hands of taxpayers to work on compliance related activities offline. This will also involve a tool that will enable taxpayers to do their business accounting in digital way. An effort is being done to enhance the GSP eco-system to onboard more service compliance activities for taxpayers.

GSTN is also engaged in creating many other value adding services like a mobile app for taxpayer facilitation, Business Intelligence using cutting edge AI/ML techniques, improved return filing procedure helping taxpayers have a prefilled return forms for filing and payment.

Case Study- Diksha

1. Executive Summary

The National Education Policy 2020 (NEP) lays down a high-level road map and goals for the country in the next 20 years - "to achieve universal access to quality education". This requires the development of digital infrastructure, use of technology for aiding learning and access to learning. India is committed to attain Sustainable Development Goals by 2030 - United Nations Sustainable Development Goal (SDG) 4 for Education, requires countries to ensure **"inclusive and equitable quality education and promote lifelong learning opportunities for all"**.

In the context of COVID-19 related disruption of schooling, DIKSHA made it possible for all states/UT's to ensure and accelerate learning/education at home through innovative programs & has been one of the top rated Free Education App on Google Play Store in India since May 2020. DIKSHA immensely helped in leapfrogging the use of technology for the benefit of teachers and learners across India.

DIKSHA policies and tools make it possible for the education ecosystem (educationist, experts, organisations, institutions - government, autonomous institutions, non-govt and private organisations) to participate, contribute and leverage a common platform to achieve learning goals at scale for the country

2. Project Overview / history of project/ need

DIKSHA (Digital Infrastructure for Knowledge Sharing) is the national platform for school education available for all states and the central government for grades 1 to 12 and was launched in September 2017. DIKSHA can be accessed through a web-portal and mobile application. DIKSHA provides access to a large number of curriculums linked e-content through several use cases and solutions such as QR coded Energized Textbooks (ETBs), courses for teachers, quizzes and others. As of July 2020, it is estimated that over 60 crore ETBs are being printed this year in India by 35 states and Union Territories, with more than 30 crore content plays and 200 crore page hits already on DIKSHA. It has 1,40,000+ e-content resources available across 30+ languages along with 500+ micro courses for teacher training for easy access and consumption during as well as post lockdown.

As part of PM eVidya announced under the Atma Nirbhar Bharat programme, DIKSHA is the '**one nation; one digital platform'** for school education in India. DIKSHA is being transformed into a platform for diverse and rich curriculum linked e-content requirements of learners and teachers for all states/UTs accessible across digital devices (laptop/mobile/desktop/tablets, TV and radio) in order to have coherence of access and learning experience.

At the same time, DIKSHA is designed to inherently support states/UTs to exercise autonomy, independence and choice to craft and run learning programs to suit their needs and achieve their goals, by using solutions, tools and data on the platform.

Objective-

Education is now increasingly resourced and conducted through digital devices to ensure continuous learning during the Covid-19 pandemic. Schools across the country have moved towards adopting various modes to facilitate teaching and learning at home. While digital or online education cannot replace classroom learning, it has some advantages. It allows flexible and personalized learning at the

speed of the learner and one can continuously augment and expand content through digital means.

3. Implementation Methodology

Principles

DIKSHA platform embodies, is designed and implemented on the basis of ten design principles and they are Shared infrastructure, Enable extensibility via platform, Create transparency and accountability, Enable extensibility via platform, Allow configurable design with plug 'n' play capabilities, Offer diverse solutions, interoperable via open standards, Distributed access via multiple delivery channels, Designed to scale via commodity computing, & Data security and privacy by design.

Building Blocks

DIKSHA is built on open source technology, made in India and made for India, which incorporates internet scale technologies and enables several use-cases and solutions for teaching and learning. DIKSHA is built using MIT licensed open-source technology called Sunbird, (initially upgraded by EkStep Foundation), which is a digital infrastructure for learning and is designed to support multiple languages and solutions and offers over a 100 micro services as building blocks for the development of platforms and solutions.

Building blocks of DIKSHA are-

1. Teacher & Leadership Training
2. Lesson Plans & Teacher Tools
3. Explanation Content
4. Practice & Homework
5. Question Banks & Exam Prep
6. Assessments
7. Quiz

Capabilities-

The vastness and diversity of India is reflected in the scale at which school education operates in the country - with about 95 lakh schoolteachers and 25 crore students, characterized by geographical, socio-cultural and linguistic diversity. Therefore, decentralised education platform like DISHA is best suited for the digital education system to work in India, keeping in view the ground realities of each State and Union Territory.

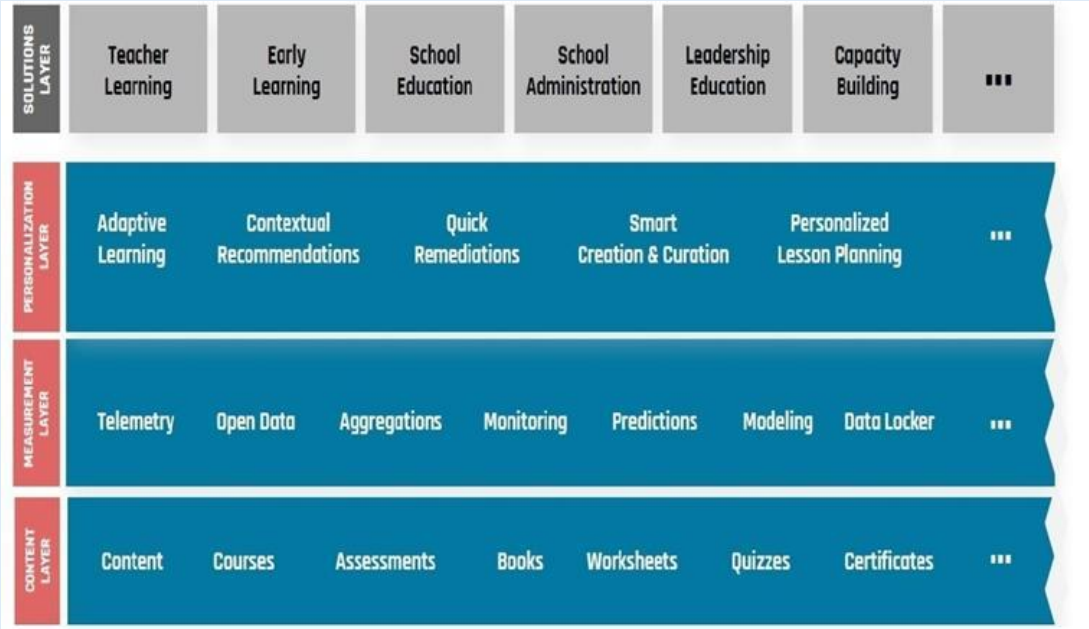
DIKSHA is a flexible and evolving platform, with the below-mentioned diverse capabilities, that will continue to evolve, based on the aggregated needs of the various states/UTs.

1. The Energised textbook solution allows educational boards to achieve that by enabling just-in-time access to digital content through QR codes printed in textbooks. This solution enables 18 crore+ students and 70 lakh+ teachers to leverage technology in the same way as a select few have been able to do so far.

2. Digital Teacher Training (DTT) courses allow roll out of structured learning programs targeted to build or enhance specific knowledge and skills for learners. Over 30 lakh teachers have been

digitally trained with the help of such courses on DIKSHA.

3. Periodic rollout of quizzes to provide an interactive format for joyful learning and promote healthy competition
4. Federated and multi-tenanted feature lets tenants like 35+ states/UTs, NCERT, CBSE are create and manage their programs on DIKSHA and help in further expanding its ever-evolving horizons.
5. Diverse content in over 20 languages propagated via various mediums like TV, radio, mobile apps, websites helps in educating diverse set of students in every part of India.
6. Features like 'Vidya Daan' help in sourcing, curating, and organizing content at scale and encourages community collaboration across the country.
7. Target user based curriculum for students ranging from early childhood to higher classes, helps in personalised & self-paced learning.
8. Compatibility with advanced technologies like Artificial Intelligence, Augmented Reality,& Virtual Reality, and its Integrability with Digi Locker makes it one stop solution every student of India in K12 Spectrum.



DIKSHA has witnessed more than 170 Crores learning sessions till date which showcases the relevance of the available e-resources as well as the integration of digital learning in the daily lives of teachers and students across the nation. It is truly an education platform for modern & digital India.

Standards

Standards used within DIKSHA include Codification standards - language, master data, etc., Content standards (SCROM and enhanced Content Markup Language), Question Markup Language (QuML) Specifications, Electronic Credential Specifications and other open standards for consent, security, etc.

Case Study- National Digital Health Blueprint (NDHB)

1. Executive Summary

The National Health Policy (NHP) 2017 defined the vision of 'health and wellbeing for all at all ages'. The policy strongly advocated the concept of **Continuum of Care**. These lofty ideals are sought to be achieved by refactoring the existing schemes and introducing several new schemes including some digital initiatives. **Citizen-centricity, quality of care, better access, universal health coverage, and inclusiveness** are some of the key principles on which the Policy is founded. This mammoth task requires that a **holistic, comprehensive and interoperable digital architecture** is crafted and adopted by all the stakeholders. In the absence of such architecture, the use of technology in the health sector continues to grow in an uneven manner and in silos.

In the above context the need for creating a framework for the evolution of **a National Digital Health Eco-system was recognized.** This has been realized by creating the **National Digital Health Blueprint (NDHB)**, which is more than an architectural document, as it provides specific guidance on its implementation as well.

The Blueprint keeps the overall vision of NHP 2017 in perspective and recommends a pragmatic agenda to start with, adopting the principle of **'Think Big, Start Small, Scale Fast'**. To this end, it has been designed as a layered framework, with the **Vision** and a set of **Principles** at the core, surrounded by the other layers relating to Digital Health **Infrastructure**, Digital Health **Data Hubs**, **Building Blocks**, **Standards** & **Regulations**, and an **Institutional Framework** for its implementation. The document also contains a high-level action plan.

2. Project Overview / history of project/ need

Healthcare has always been central to all development efforts be it a national or global agenda. Government of India envisages as its goal the attainment of the highest possible level of health and well-being for all at all ages and intends to provide universal access to good quality health care services without anyone having to face financial hardship as is enunciated in National Health Policy, 2017.

The most promising approach adopted by National Health Policy towards this goal is extensive deployment of Digital Tools/Technology to enhance health system performance. Government is committed to Universal Health Coverage for all citizens; to make healthcare affordable, accessible, and equitable, and Digital Health technology has a huge potential for supporting Universal Health Coverage (UHC).

Ministry of Health and Family Welfare (MoHFW) prioritized the utilization of Digital Health to ensure effective "service delivery" and "citizen empowerment" so as to bring significant improvements in the public healthcare delivery.

To improve efficiency in healthcare delivery, extend healthcare to rural areas and provide better quality services at low cost, certain eHealth initiatives using ICT (Information and Communication Technologies) were undertaken by MOHFW across the country with the following objectives.

- To ensure availability of services on wider scale
- To address the human resource gap by efficient & optimum utilization of the human resources existing in the health sector
- To provide healthcare services in remote & inaccessible areas through telemedicine
- To improve patient safety by access to medical records and help reduce healthcare cost
- To monitor geographically dispersed tasks for meaningful field level interactions through effective use of MIS
- To help in evidence-based planning and decision making, and
- To improve efficiency in imparting training and in capacity building

The **Objectives** of NDHB are aligned to the Vision of NHP 2017 and the SDG's relating to the health sector. These include:

a. Establishing and managing the core digital health data and the infrastructure required for its seamless exchange;

b. Promoting the adoption of open standards by all the actors in the National Digital Health Eco-system, for developing several digital health systems that span across the sector from wellness to disease management;

c. Creating a system of Personal Health Records, based on international standards, and easily accessible to the citizens and to the service providers, based on citizen-consent;

d. Patient is the owner of his/her EHR and the health facilities and government entities maintain the data under trust on behalf of patient. The collection as well as the end use of the data shall be through a consent framework. The anonymized data can however be used for the research purposes duly following the principles so defined. It is the responsibility of the health facility to ensure privacy, security and confidentiality of the data.

e. Following the best principles of cooperative federalism while working with the States and Union Territories for the realization of the Vision;

f. Promoting Health Data Analytics and Medical Research;

g. Enhancing the efficiency and effectiveness of Governance at all levels;

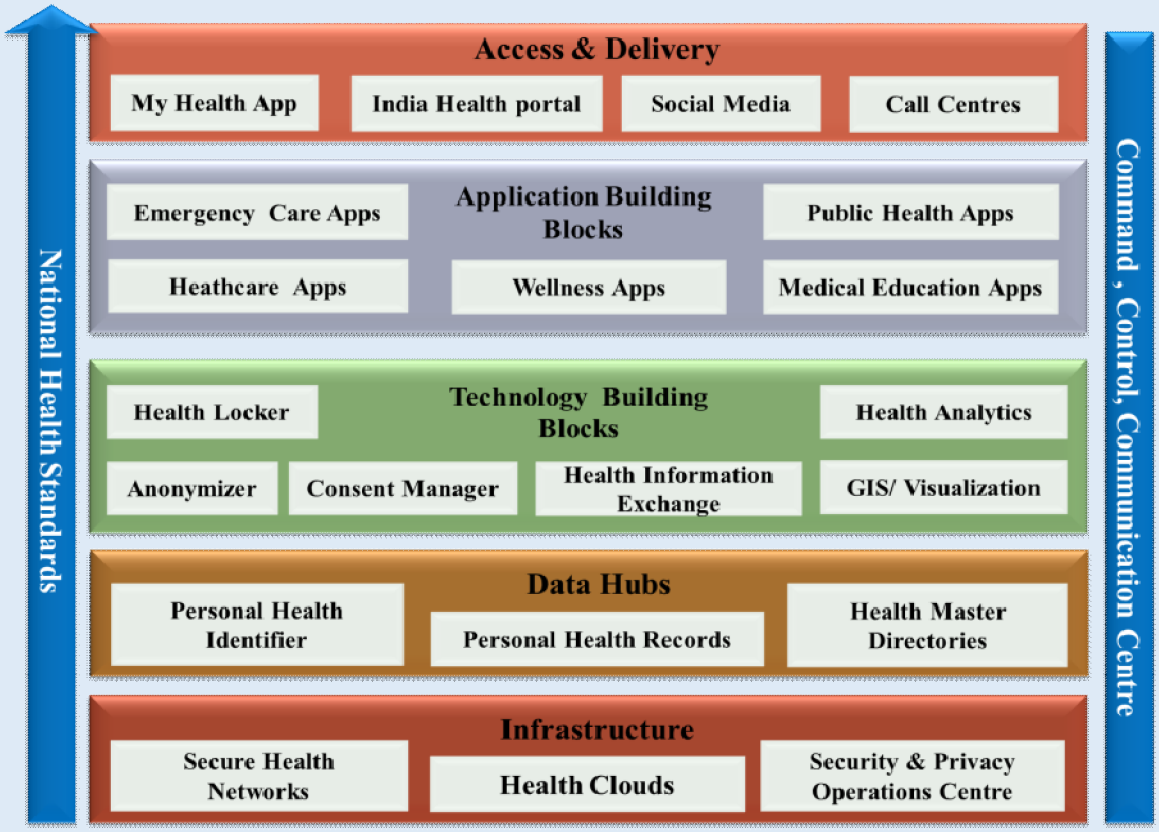
h. Ensuring Quality of Healthcare.

i. Leveraging the Information Systems already existing in the health sector.

3. Implementation Methodology

Principles

An eco-system cannot be *built* – it must *evolve*. Given this, **a set of Principles - rather than specifications** - were recommended to enable the evolution of National Digital Health Ecosystem. The key principles of the Blueprint include, *from the domain perspective*, Universal Health Coverage, Inclusiveness, Security and Privacy by Design, Education and Empowerment of the citizens, and *from the technology perspective*, Building Blocks, Interoperability, a set of Registries as Single Sources of Truth, Open Standards, Open APIs and above all, **a minimalistic approach**.



Building Blocks

Building blocks are reusable frameworks or artefacts that most stakeholder groups need to rely upon for designing, developing and delivering their services. The Blueprint identifies the **Minimum Viable Set of**

Building Blocks required for the health ecosystem to evolve and describes their capabilities at a high-level. It is for the implementing organization, to arrange for the design, development and establishment of the Building Blocks. Conformance to the NDHB Principles on one side and to the NDHB Standards & Regulations on the other side, are critical for an efficient design and development of the Building Blocks.

Based on the study of the existing health systems, discussions with stakeholders and analysis, 35 key Building Blocks have been identified across the 3-Level/4-layered architecture of NDHB. These have been represented in the above Figure.

A few of the critical capabilities of heath ecosystem, addressed by appropriate combinations of the Building Blocks, are explained briefly along with a schematic of the Blueprint:

1. **Identification**: Unique identification of Persons, Facilities, Diseases and Devices is a key requirement and challenge as well. The Blueprint handles this requirement through 2 Building Blocks, namely, Unique Health Identifier (UHID) in tandem with Health Locker. This is envisaged to create and maintain Electronic Health Records and Personal Health Records.

2. **Citizen to be in Control**: The need for maintaining the confidentiality, security and privacy of the health records cannot be over-emphasized. These regulatory requirements are built into the design, rather than being retrofitted. The Blueprint achieved these complex and mandatory requirements through a combination of a few Building Blocks, namely, **Consent Manager, Anonymizer and Privacy Operations Centre**. Besides these Building Blocks, application-specific features and relevant International standards defined in the Blueprint fortify the privacy regime.

3. **Service Access/ Delivery**: Omni-channel access/ delivery are an important capability required in NDHE. This is achieved by a combination of Web (**India Health Portal**), Mobile (**MyHealth App**) and **Call Centres** besides **Social Media Platforms**. The Unified Communication Centre enables real-time monitoring and real-time interventions needed in the health ecosystem.

4. **Interoperability**: The most important contribution of the Blueprint is its advocacy of Interoperability, which is a pre-requisite for development of integrated digital health services and continuum of care but also for the autonomous development of innovative value-added services by entrepreneurs. Two Building Blocks, namely, the **Health Information Exchange** and the **National Health Informatics Standards** enable and promote the interoperability of various building blocks.

These building blocks are allocated under a high-level federated model with three levels of roles delineated between Centre, State and Health Facilities. Except for the minimum data set needed at Centre and State level the data shall primarily reside at health facility level.

The Application Layer of the Blueprint is merely a placeholder in so far as it identifies the **thematic areas** for development and deployment of **applications** but refrains from listing them exhaustively. Such an approach is adopted not only because of the large number and variety, but also because the applications must evolve in an innovative way that cannot be defined upfront. Taking the legacy applications on board to the NDHE requires that each application is rigorously assessed w.r.t it's conformance to the standards, using a set of criteria like that defined by the Digital Service Standard, notified by Ministry of Electronics and Information Technology, GoI.

The value of the Blueprint can be realized mainly in terms of the impact the Digital Health Services make on the various stakeholder groups. The Blueprint provides an illustrative, but by no means exhaustive list of **Digital Health Services**, to indicate the nature of qualitative difference its implementation can make. Needless to say that the portfolio of services must be validated and updated through a series of consultations with the stakeholder groups.

Standards

The health sector must adopt the international standards in a large number of areas. However, The Blueprint has adopted a pragmatic approach and recommended only the minimum viable set of standards, to make it easier for the eco-system players to adopt the same. FHIR Release 4 (in a highly condensed form), SNOMED CT and LOINC are among the standards recommended.

4. Future Roadmap/ Sustainability

A Blueprint is only as good as its implementation. An appropriate **Implementation Framework** is suggested in the table below. The role and functions of the implementing organization have been

recommended.

Year 1 (Planning & stabilizing NDHM)	Year 2 (Pre-requisite infrastructure)	Year 3 (Execution)	Year 4 (Analytics & Innovation)	Year 5 (Sustenance & Research)
ŏ Design and Development of Federated Enterprise Architecture, adopting MeitY's Agile IndEA Framework. ŏ Design of Core Building Blocks and defining their standard interfaces ŏ Assessment of legacy systems for conformity with NDHB. ŏ Design and notification of Health Security & Privacy Policies ŏ Design and development of Consent Management Framework	ŏ Designing and establishing Unique Health Identifier (UHID), directories of health professionals & health institutions ŏ Design and implement federated health cloud & secure network infrastructure. ŏ Enhancing of Legacy systems to conform to NDHB Principles, and interoperable ŏ Implementation of a plan for adoption of Health Informatics Standards including Electronic Health Record (EHR) for citizen with family folders	ŏ Establishing Health Information Exchange (HIE) ŏ Design, develop and launch Common Applications ŏ Establish Health App Store ŏ Design and implement Capacity Building Plan ŏ Establish the Repository of Standards, API's, Metadata and Data Dictionaries	ŏ Implementation of Artificial Intelligence enabled Clinical Decision Support systems ŏ Designing and developing Health Analytics platform ŏ Design and develop Anonymization methodology for health data analytics ŏ Establish SOC, NOC and Privacy Operations Centre (POC) ŏ Design and notification of Framework for Value-Added Services	ŏ Ensuring Continuum of Care ŏ Continued Research ŏ Sustenance of Operations

Annexure 4: Indicative list of Common and Reference Building Blocks at National / Sate Level

#	Service	Description	Available Software
1.	Services Directory	Directory of all G2C and G2B services	India Portal
2.	Collaborative Governance	Collaborative engagement with the citizens	MyGov
3.	Grievance Management related to citizens	Central System for taking citizen grievances	CGRAMS
4.	Integrated Service Management	Hand-held access to all G2C services of the Government and citizen feedback	Umang
5.	Single Sign On	OAuth 2.0	DigiLocker
6.	Integrated Call Center	Emergency response center	112 Call Center
7.	Document Management System (External)	Electronic document management for citizens with nomination facility	DigiLocker
8.	Email Gateway (External)	Mass email messaging to citizens	eSampark
9.	SMS Gateway	SMS to citizens	mSeva
10.	Payment Gateway	Electronic payment address	UPI, BHIM
11.	eSign	Electronic signature	eSign
12.	Messenger System	Real time messaging	Sandes
13.	Linguistic Support	Real time electronic translation and transliteration	eBhaasha, NLTM
14.	API Gateway	Electronic data exchange	API Setu
15.	Document Management System (Internal)	Government document management	eOffice
16.	Email Gateway (Internal)	Government eMail	@gov.in
17.	Video Conference	Audio and Video conferencing services	VidyoConnect
18.	SSO Access Management (Internal)	Electronic access for government officials (Authorization)	eParichay
19.	Service Delivery Monitoring	Real Time Tracking of G2C service delivery to citizens	eTaal
20.	Financial Management	Public Financial Management System	PFMS
21.	Government Procurement	Government eMarketplace for products and services	GeM
22.	Court Management System	Manage all cases where Government is directly involved as one of the parties	eCourts
23.	Website Development	Easy website development	Swayam
24.	Land Records	Electronic Land Records Management	BharatMaps, NCoG
25.	Programming for Services	Easy programming for service delivery	ServicePlus
26.	Collaborative SW Development	Versioning management	Open Forge
27.	Appstore	Store-house of electronic applications	eGov Appstore
28.	Cloud Services	Provide cloud services IAAS, PAAS	MeghRaj

Annexure 5 : Suggested curriculum for InDEA CB Courses and InDEA Certificate Course

InDEA 2.0 Training Modules

For the GOVT Staff

a. Foundation Modules / Common Modules List of Topics and Relevance to the Preferred Themes (Suggested 3 X 1 Hour Session + 2 X 1-hour Session Q & A/ Interactive) (For Administrative and Policy Strems)

Abstract: - The goal of this course module is to provide an overview and a general idea of digital governance in the form of InDEA 2.0 - the overarching vision of Digital India Program. Digital governance is often defined as the adoption and use of Information and Communication Technologies (ICT), in particular the internet, to transform the relationship between government and society in a positive manner. The major reform paradigm of digital governance is moving towards an entrepreneurial approach synchronizing with the functional hierarchy of the government. In case of InDEA 2.0, this transforms to entrepreneurial architectural approaches in a Federated Hierarchy with Privacy in focus.

Learning Objectives

- Governance, People and technology
  - The realm of Public Services
  - People and Process
  - Administration Management Governance and Services
  - Digital Divide and closing the gap
  - The Entrepreneurial approach
- Digital Governance – The fundamentals
  - The scope and relevance of Digitization
  - Sample Digitization – A practical example
  - The scope and relevance of Technology
  - Sample elements of Technology - A Practical example
  - The concept of “Enterprise” and relevance to Governance
  - Digital ID
- The road so-far and road ahead
- Success factors
- Precursors to InDEA 2.0 with a live example
- InDEA 2.0 and a sample scenario

b. Administrative Module (Suggested 3 X 1 Hour + 2 X 1 hour of Q&A/ Interactive)

Abstract: - The goal of this course module is to provide background of generic thought process and concepts that are crucial for InDEA2.0 laying the foundation for the importance of administrative aspects of EA in hierarchical governance. The advanced aspects of technology are introduced in a gentle way. The module wraps us with focus on significance of factors like privacy performance etc. in InDEA2.0.

Learning Objectives

- Governance Services and Technology
    - Digital Government Projects as Multidimensional Initiatives
    - The idea of Federation in administration and governance
    - The idea of autonomy and centralization
    - Technology as an indispensable tool and an enabler
    - The idea of Federation in technology adoption
    - Functional and conceptual components of technology
    - Administrative aspects of technology
    - Ease of use and User experience
    - Adoption and proliferation of technology
    - SOE and Digitization
    - Architectural aspects of a Digitalization SOE
    - EA in other countries
- Fundamental Components
    - Functional components
    - Infrastructure components
    - Gentle introduction to Data, information, UI, Dashboards
    - Gentle Introduction to design architecture and components
    - Gentle introduction to Backend and Front end and Middleware
    - Gentle introduction to IT hardware and communication infrastructure
- Some success Factors
    - Performance, quality, capability, usability and availability
- Privacy, AAA, security, provenance

c. Policy Module (Suggested 3 X 1 Hour Session + 2 X 1 Hour Session [Q&A/ Interactive])

Abstract: - The goal of this course module is to provide deeper insights of thought process and concepts that are crucial for InDEA 2.0 laying the foundation for the importance of policies related to technology. They are crucial enablers to the success of InDEA 2.0. The advanced aspects of technology are introduced in a gentle way. The module wraps us with focus on significance of factors like privacy, AAA, security, provenance performance, quality, capability, usability and availability for the success of InDEA 2.0

Learning Objectives

- E-Governance, Digital governance and Enterprises
    - Defining E-processes, E-administration, E-management and E-governance, E-Services
    - Defining, managing Data and Information and their flows
    - Defining E-Services, Autonomy
    - Defining E-boundaries of sectors and interfaces
    - Defining Functional, Technical architectures
    - Architectural and Design Patterns of EA

- Building Blocks of EA
  - Definitions, Functions and Specifications
  - Re-usable components
  - Standards and SOA (State of Art)
  - Approaches towards building "blocks"
  - Types of Building Blocks
  - Tools for EA.
- Policy and technology
  - Technology aligned Policies of Vision, Capacity, Competency
  - Technology aligned Policies for adoption and proliferation
  - Technology aligned capability and performance model
  - Scalability and Migration
  - Federated architecture for technology proliferation in governance
  - Infrastructure provisioning
  - Sectorial interfaces and interoperability
  - Business policies (purchase, service, contracts, development, maintenance etc.)
  - IT Services/Resources as Commodities
  - Technology and Vendor neutralism
  - Services, Performance and Availability
  - Open source approaches
  - Emerging technologies and ease of their adoption
  - PPP – GOI Policies
- Accommodating the Data Legislation/Laws
  - Preserving privacy, AAA, non repudiation, security, provenance etc.

d. Technology Stream

(Two days [Suggested 3 X 1 Hour Session + 2 X 1.5-hour Session [Q & A/ Interactive] for each day])

Abstract: - The goal of this course module is to provide complete heads up and deep insights in to technology and trends for EA. The module wraps us with focus on infrastructure provisioning for Enterprise Federated Architecture.

Learning Objectives

- Data and Technology Primer
  - Introduction to Big Data
  - Query Engines
  - Storage Engines
  - Analytics
  - Ingestion and Orchestration
  - Platforms (OS)
  - DR DC
  - Virtualization
- Big Data Frame works
  - Hadoop, Apache Spark
  - Infrastructure
  - Clusters and Clouds

- Compute and Storage
- Networking

- Security, Privacy, Availability, Performance (in Infrastructure Provisioning)
- Emerging Technologies
  - AI IOT Block chain and Trends.

e. Case study and Discussion (3 X 1 Hours + Oral presentation QA and debate for each group, wrap-up for each of the above modules) – **Optional/Place Holder**

Abstract: -The goal of this course module is to discuss significant roadmaps towards InDEA 2.0 by comparing and contrasting with digital governance adoption in India and in other countries. A short write up on EA, digitization experience would be provided to all members to work upon. Each of the group (administrative / policy/technology) would be divided in to small teams and come up with ideas and framework as they see. Each group would present their learnings followed by a debate and QA.

For the Professionals

a. Foundation 1 – Common Module (1) List of Topics and Relevance to the Preferred Themes

(One day (Suggested 3 X 1 Hour Session + 2 X 1.5-hour Session [Q & A/ Interactive])

Abstract: -The goal of this course module is to provide an overview and a general idea of digital governance in the form of InDEA 2.0- the overarching vision of Digital India Program. This module gives a heads up to both Architectural and Technology streams from the view point of governance.

Learning objective

- Digital Governance
  - The role of private enterprises and professionals
  - Products and Services
  - Participatory growth
  - Digital ID, E-processes, E-administration, E-management and E-governance, E-Services
  - Data, information, UI, Dashboards
  - The Backend and Front end and Middleware
  - IT hardware and communication infrastructure
  - IT Services/Resources as Commodities
  - Technology and Vendor neutralism
  - Open source approaches
  - PPP – GOI Policies
- Building Blocks of EA
  - Functions and Specifications
  - Re-usable components
  - Standards and SOA (State of Art)
  - Approaches towards building “blocks”

  - Types of Building Blocks
  - Design/Architecture and technology/infrastructure components
  - Tools for EA.
- Program Management
  - Design, deployment, Service, Performance and Availability Guarantees
- Data Legislation/Laws
  - Privacy, AAA, non repudiation, security, provenance etc.

b. Architectural Stream

(Two days [Suggested 3 X 1 Hour Session + 2 X 1.5-hour Session [Q & A/ Interactive] for each day])

Abstract: - The goal of this course module is to provide complete heads up and deep insights in to EA models, tools and trends. The module wraps us with focus on components of EA

Learning Objectives

- Enterprise Architecture and Technology Trends
  - Views, tools and languages
  - Ontologies in EA
  - Adopting the Technology layer
  - Data, Information and Interfaces
- Security and Privacy by design
- Federated Approach
  - Architecture, Data and Digital IDS
- Detailed exposure to India specific Models (and Development methodology)
  - IndEA1, IndEA2

c. Technology Stream

(Two days [Suggested 3 X 1 Hour Session + 2 X 1.5-hour Session [Q & A/ Interactive] for each day])

Abstract: - The goal of this course module is to provide complete heads up and deep insights in to technology and trends for EA. The module wraps us with focus on infrastructure provisioning for Enterprise Federated Architecture.

Learning Objectives

- Data and Technology Primer
  - Introduction to Big Data
  - Query Engines
  - Storage Engines
  - Analytics
  - Ingestion and Orchestration
  - Platforms (OS)
  - DR DC
  - Virtualization
- Big Data Frame works
  - Hadoop, Apache Spark

- Infrastructure
- Clusters and Clouds
- Compute and Storage
- Networking

- Security, Privacy, Availability, Performance (in Infrastructure Provisioning)

d. Foundation 2 – Common Module (2)

(Two days (Suggested 3 X 1 Hour Session + 2 X 1.5-hour Session [Q & A/ Interactive] for each day)

Abstract: - The goal of this course module is to provide complete heads up and deep insights in to Case Studies of Aadhaar, GSTN, DIKSHA and NDHB implementation Case studies of Emerging Technologies and their Program Management.

Learning Objectives

- Case studies of
  - AADHAR, GSTN, DIKSHA, NDHB
    - Design, Architecture, Infrastructure
    - Early Challenges
    - Implementation and Adoption Success.
- Emerging Technologies
  - AI IOT Block chain and Trends.