



HARMONIZING NIGERIA'S **DIGITAL** **FRONTIER**

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A Conceptual Exposé on Standardization, Integration and Interoperability in E-government

A White Paper



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List of Acronyms and Abbreviations

API	Application Programming Interface
AS4	Application Statement 4
B2B	Business to Business
BI	Business Intelligence
BVN	Bank Verification Number
CBN	Central Bank of Nigeria
DPI	Digital Public Infrastructure
EDGI	E-Government Development Index
EU	European Union
FinTech	Financial Technology
FIRS	Federal Inland Revenue Service (now NRS: Nigeria Revenue Service)
FRSC	Federal Road Safety Corps
G2B	Government to Business
G2C	Government to Citizen
G2E	Government to Employee
G2G	Government to Government
GDPR	General Data Protection Regulation
GPA	Generative Process Automation
GraphQL	Graph Query Language
gRPC	Google Remote Procedural Call
HTTP	Hypertext Transfer Protocol
ICT	Information and Communication Technology
ID	Identification
IS	Information System
ISO	International Standards Organisation
MDA	Ministry, Department and Agency
MDM	Master Data Management
MEDGI	Middle EDGI Ranking
MIME	Multipurpose Internet Mail Extension
mTLS	Mutual TLS

NATO	North Atlantic Treaty Organisation
NCC	Nigerian Communications Commission
NDPA	Nigeria Data Protection Act
Ne-GIF	Nigeria e-Government Interoperability Framework
NGDX	Nigeria Data Exchange
NIIS	Nordic Institute for Interoperability Solutions
NIMC	National Identity Management Commission
NIN	National Identity Number
NINAuth	NIN Authentication
NIS	Nigeria Immigration Service
NITDA	National Information Technology Development Agency
NRS	Nigeria Revenue Service
OCSP	Online Certificate Status Protocol
PKI	Public Key Infrastructure
Q1	First Quarter
REST	Representational State Transfer
SOAP	Simple Object Access Protocol
TLS	Transport Layer Security
UN	United Nations
UPI	Unified Payment Interface
UXP	Unified Exchange Program

Executive Summary

Over the last decade, there has been a slow but steady transition to e-government in Nigeria; year in, year out, several government organizations and institutions make headlines with the deployment of portals, applications or enterprise systems, with each deployment often presenting its own unique sets of features and promises, which most often than not are limited to the service borders of the organization.

Nigeria's digital transformation is at a crossroads. While individual ministries, departments, and agencies (MDAs) have made strides in digitization, the public sector remains a collection of "digital islands."

This white paper outlines a strategic conceptual model to bridge these gaps in consideration of the Nigeria e-Government Interoperability Framework (Ne-GIF) and the emerging Digital Public Infrastructure (DPI). The goal is to move from fragmented portals in silos to a "**Whole-of-Government**" or "**Single Window**" approach that lowers costs, increases efficiency and improves overall citizens' experience. It x-rays Estonia's X-Road® architecture and comparatively analyses some popular data exchange & interoperability architectures.

The final conceptual model presented in this whitepaper aligns with the Ne-GIF standards¹; expands and reinforces the X-Road® architecture², and consolidates the precepts of the anticipated NGDX³ for a seamless e-government eco-system in Nigeria.

¹ NITDA (2019), *Nigeria e-Government Interoperability Framework*; online available at: <https://nitda.gov.ng/wp-content/uploads/2020/11/Ne-GIFFinal1.pdf>; accessed in March 2026.

² Nordic Institute for Interoperability Solutions, NIIS (2026), *X-Road Architecture*; online available at: <https://x-road.global/architecture>; accessed in March 2026.

³ NITDA (2025), *Nigeria introduces data exchange platform to end repeated data submissions by citizens*; published by Nairametrics; online available at: https://nairametrics.com/2025/08/25/nigeria-introduces-data-exchange-platform-to-end-repeated-data-submissions-by-citizens/#google_vignette; Author: Samson Akintaro; published on 25th August 2025; accessed in March 2026.

1. Synopsis of E-Government

Simply put e-government is the application of information and communication technologies (ICT) for delivering government services, exchange of information, communication, transactions, etc. It involves the integration of various stand-alone or connected systems for service delivery from government-to-citizen (G2C), government-to-business (G2B), government-to-government (G2G), and government-to-employees (G2E). The figure below summarises the types of e-government.

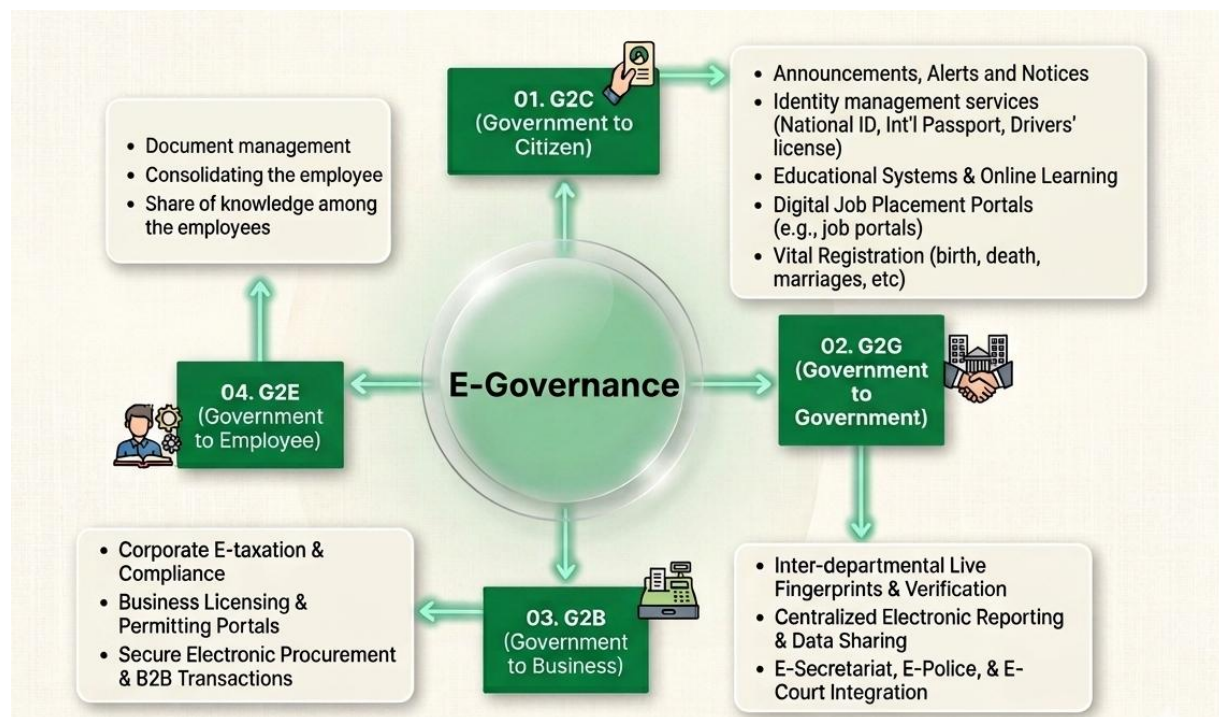


Figure 1: Types of E-Government

Image concept adapted from <https://schoolofpoliticalscience.com/what-is-e-governance/>

2. Status Quo of e-Government in Nigeria

There are no fewer than sixty (60) publicly available e-government systems in Nigeria. With a broadband penetration of 53.07%, tele density of 84.06% and over 150 million subscribers as of January 2026⁴, one could argue that Nigerian citizens and business are poised to embrace and enjoy a truly digital regime; however, this is not the case today as user experience for e-government is marred by a number of challenges such as low digital literacy, poor awareness of existence of e-government systems, bureaucracy in government service delivery, reluctance to change, inadequate digital infrastructure (especially in rural areas), poor electricity supply, cybersecurity & data privacy concerns etc.

Less than 50% of critical government services are accessed and used by Nigerians via self-service; many individuals and businesses still favour physical interaction and visit to these government agencies.

The United Nations (UN) e-government development index (EDGI) ranked Nigeria 144th of 193 countries in the 2024/2025 EDGI report. Ghana emerged as the regional leader in West Africa while South Africa emerged as continental leader. Between 2020 and 2025, Nigeria has remained in the lower middle-tier globally.⁵

Table 1: Nigeria's EDGI Ranking from 2020 to 2024/2025

Year	Global Rank	EGDI Score	Rating Class
2024 / 2025*	144th	0.4815	Middle EGDI
2022	140th	0.4525	Middle EGDI
2020	141st	0.4406	Middle EGDI

⁴ NCC (2026), *Industry Statistics*, online available at <https://ncc.gov.ng/market-data-reports/industry-statistics>; accessed in March 2026.

⁵ United Nations (2026), *E-Government Knowledgebase*, online available at: <https://publicadministration.un.org/egovkb/en-us/Data/Country-Information/id/125-Nigeria>; accessed in January 2026.

3. The Problem with E-Government Harmonization in Nigeria

Current e-government efforts in Nigeria face five primary roadblocks as shown in the figure below.

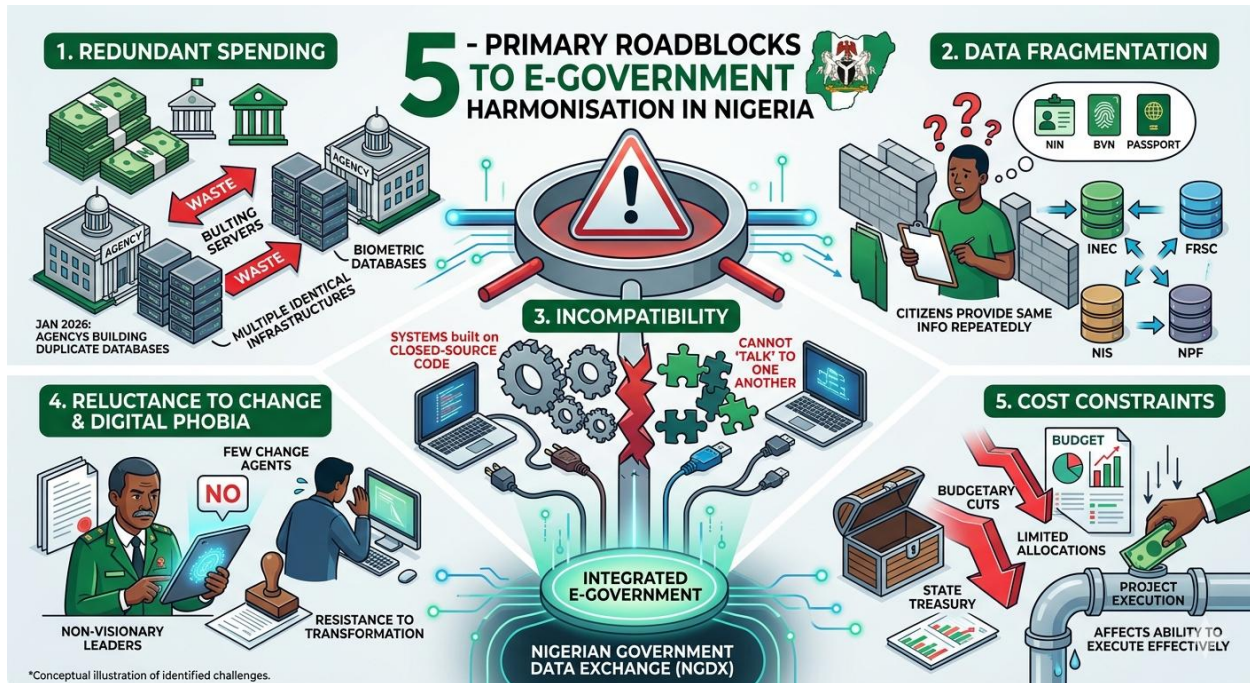


Figure 2: Primary Roadblocks to E-Government Harmonization in Nigeria

- a. **Infrastructure Overlap (Redundant Spending):** Despite the central mandate of NIMC, several agencies (NIS, INEC, FRSC, etc.) continue to allocate significant portions of their annual budgets to building and maintaining their own independent biometric hardware and data centres. This results in the government paying multiple times for the same type of infrastructure.
- b. **Data Fragmentation (Enrolment Fatigue):** This is the most visible barrier for the average Nigerian citizen. Because databases are not yet fully linked via the NGDX, a Nigerian must physically visit different offices to capture the same fingerprints and facial data for their Passport, Voter's Card, and Driver's License, leading to massive data silos.
- c. **Incompatibility (Due to Closed Systems):** Many legacy systems in Nigerian government agencies were built using closed-source, proprietary software from different vendors. These systems often lack standardized APIs (like REST or SOAP), making it technically difficult and expensive for integration.
- d. **Reluctance to change & Digital Phobia:** Technology is only as effective as the people driving and managing it. In some agencies, a lack of digital leadership and a

fear that automation will reduce "manual control" (or opportunities for rent-seeking) creates a culture that resists moving toward a transparent, harmonized system.

- e. **Cost Constraints (Funding Gap):** Even when a government agency is willing to modernize, Nigeria's fluctuating economy and budgetary cuts often mean that IT projects are the first to be de-prioritized. Without consistent, multi-year funding, many agencies cannot afford the high-end secure servers and skilled personnel required to execute effectively and operate in the NGDX regime.

NOTE: The Nigerian government through the National Information Technology Development Agency (NITDA) is deploying the Nigerian Data Exchange Platform (NGDX) to address some of the data sharing and interoperability challenges⁶.

Also, the NINAuth platform managed by NIMC, aims to provide a secure and reliable way for Nigerians to share their National Identification Number (NIN) data⁷.



⁶ NITDA (2025), *NITDA Rallies Stakeholders in Co-creating DPI, NGDX, for Effective Nationwide Digital Inclusion*; published 1st December 2025; online available at: <https://nitda.gov.ng/nitda-rallies-stakeholders-in-co-creating-dpi-ngdx-for-effective-nationwide-digital-inclusion/9244/>; access in January 2026.

⁷ NIMC (2026), *NINAuth: Nigeria's Trusted Identity Gateway*, online available at: <https://ninauth.nimc.gov.ng/about-nin-auth/>; access in March 2026.

4. Overview of Selected Data Exchange & Interoperability Architectures

There is an increasing paradigm shift in the adoption of decentralized architecture for digital government platforms. Notable e-government architectures include X-Road (Estonia), Trembita (Ukraine), Unified Exchange Platform (Benin), e-Delivery (European Union). As of March 2026, **X-Road** has become a global *de facto* standard for secure, decentralized data exchange, with more than 25 countries and territories adopting it or very similar architectures to build their Digital Public Infrastructure (DPI)⁸.

These systems all aim to solve the problem of "digital islands" or "silozed databases" across different government agencies.

4.1 The X-Road Architecture Summary

X-Road is a centrally managed, distributed data exchange layer that enables secure, Internet-based data transport between information systems. It acts as a "digital highway" or middleware that creates a standardized and secure ecosystem⁹. A high-level depiction of the X-Road architecture is shown below.

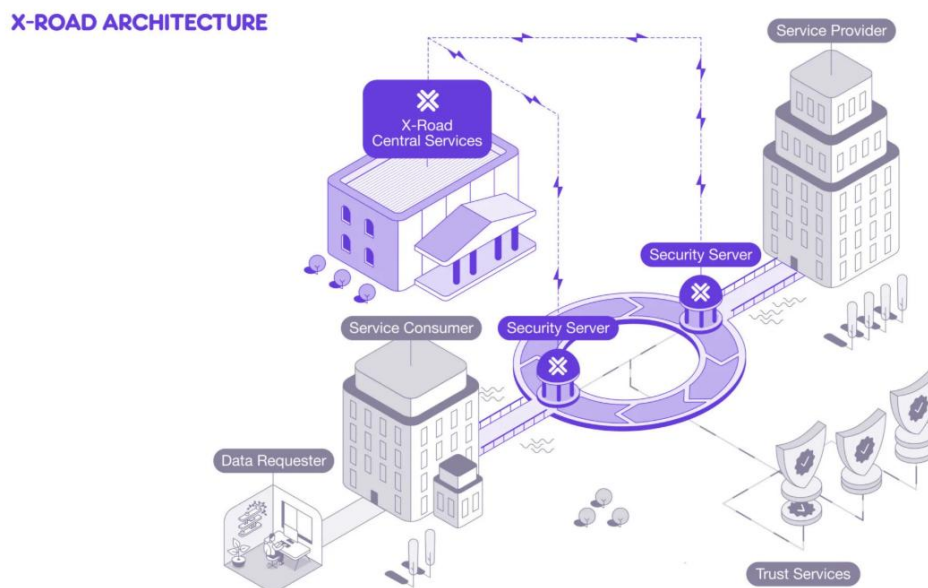


Figure 3: X-Road Architecture

Image Source: <https://x-road.global/architecture>

⁸ GovTech Intelligence Hub (2025), *Smarter Data Exchange: How X-Road Became a Model for Digital Public Infrastructure*; online available at: <https://www.govtechintelhub.org/case-study-details/smarter-data-exchange:-how-x-road-became-a-model-for-digital-public-infrastructure/aJYTG0000000o014AA>; published on 18th June 2025; accessed in January 2026.

⁹ Nordic Institute for Interoperability Solutions, NIIS (2026), *X-Road Technology Overview*; online available at: <https://x-road.global/x-road-technology-overview>; accessed in March 2026.

Key Architectural Principles in X-Road

- **Distributed/Decentralized:** Data is not stored centrally. It remains at its source within the existing databases and information systems of the participating organizations (both public and private).
- **Security by Design:** All data exchanges are strictly identified, categorized, and secured. X-Road ensures integrity, non-repudiation, and confidentiality by applying digital signatures and timestamping to all messages using qualified certificates.
- **Interoperability:** It provides a standardized interface (via Security Servers), allowing diverse, heterogeneous information systems to communicate regardless of their underlying technology or vendor.

In X-Road, data is always exchanged directly between a service consumer and a service provider. There is no centralized message broker or data intermediary and hence, third-parties don't have access to the data. The service provider is always in full control of who/what is allowed to access its data and services¹⁰.

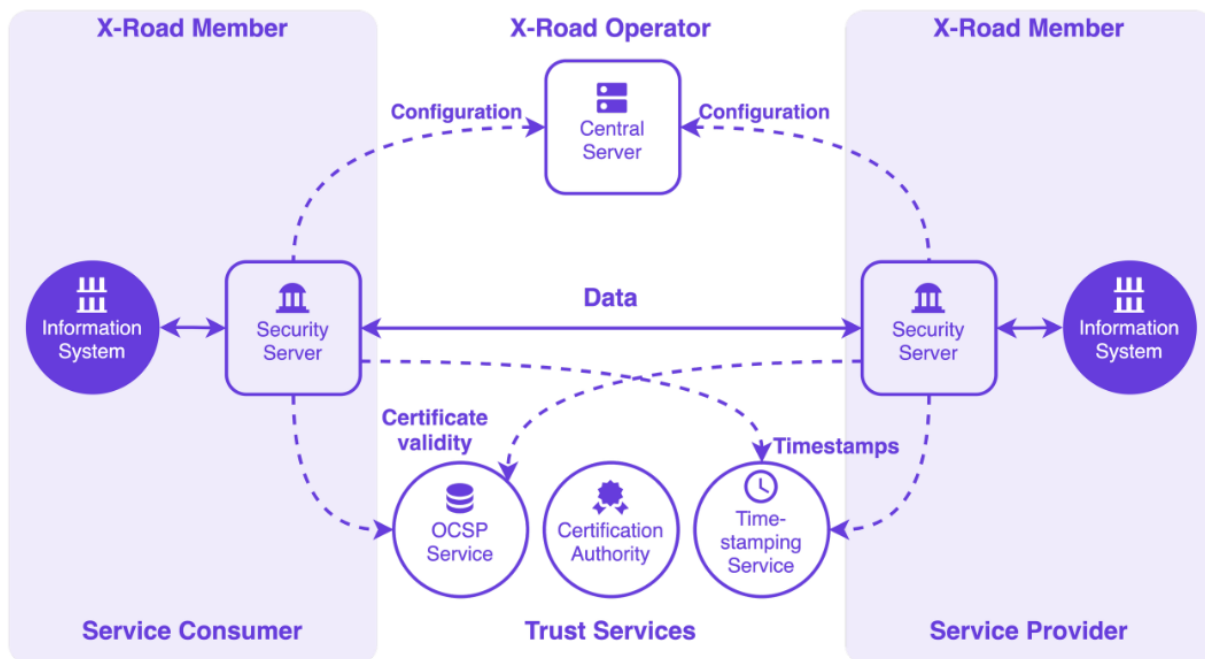


Figure 4: Data Exchange in X-Road
Image source: <https://x-road.global/data-exchange>

¹⁰ Nordic Institute for Interoperability Solutions, NIIS (2026), *X-Road Data Exchange*, online available at: <https://x-road.global/data-exchange>; accessed in February 2026.

Steps/Flow in the X-Road Data Exchange

- a. The service consumer information system initiates a data transaction by sending a request to the service consumer Security Server.
- b. The service consumer Security Server signs and logs the request and routes it to the service provider Security Server. The connection between the Security Servers is secured using mutual TLS (mTLS).
- c. The service provider Security Server verifies and logs the request and forwards it to the service provider information system.
- d. The information system processes the request and returns a response to the service provider Security Server.
- e. The service provider Security Server signs and logs the response and forwards it to the service consumer Security Server. The connection between the Security Servers is secured using mTLS.
- f. The service consumer Security Server verifies and logs the response and forwards it to the service consumer information system.
- g. The service consumer information processes the response.

KEY INSIGHT: If any of the verification steps fail, the data transaction is terminated and an error message is returned to the consumer information system.

The data exchange process does not include the Central Server or trust services. Rather, their services are used asynchronously in the background by the Security Server. This allows an X-Road ecosystem to function without the Central Server and trust services for extended periods of time (hours to days, depending on the configuration).

[Source: Nordic Institute for Interoperability Solutions, NIIS (2026), *X-Road Data Exchange*; online available at: <https://x-road.global/data-exchange>]

4.2 Comparative Analysis of Data Exchange & Interoperability Architectures

A number of data exchange architectures inspired by X-Road have emerged in the last 5 years. Finland, Columbia and Cambodia have adopted and integrated X-Road into their e-government ecosystem. The UXP and Trembita data exchange systems are the closest implementations to X-Road. UXP is used by governments of Aruba, Bahamas, Benin, Greenland, Haiti, Namibia, Tunisia, and Ukraine, also by the financial sector in Japan, healthcare sector in the US and has been piloted by NATO¹¹. Nigeria’s NGDX is based on the X-Road. The table below shows a comparative analysis of data exchange architectures.

Table 2: Comparative Analysis of Data Exchange Architectures for e-Government

Feature Category	X-Road (Estonia)	UXP (Cybernetica)	Trembita (Ukraine)	eDelivery (EU)	India Stack (India)	MConnect (Moldova)
Architectural Model	Distributed (Peer-to-Peer) Centrally managed configuration; direct data exchange.	Distributed (Peer-to-Peer) Technologically identical model to X-Road.	Distributed (Peer-to-Peer) Model highly similar to X-Road.	Distributed (4-Corner) Standardized gateways (Access Points) connecting diverse nodes.	Siloed & Federated components Branded as unified, but operates as separate closed systems (ID, Pay, Data)	Distributed/Real-time National platform for direct, real-time data exchange.
Trust Model	Central Authority defines trusted CAs and TSAs. Mutual trust is automatic within the ecosystem	Similar to X-Road; Central Authority manages member registry and security policy	Based on digital certificates, guaranteeing non-repudiation of messages.	Multiple trust models supported. Trust is established within a specific policy subdomain (e.g., eHealth)	Required permission at every layer. Gatekeeper decides access; limited citizen representation	Standardized application to Electronic Governance Agency required for access
Primary Deployment Scope	Nationwide Cross-Sector Designed for interaction between ALL public and private sector organizations.	Vertical or Horizontal Domain-independent; can be nationwide or limited to a specific sector/criteria.	State Resources Primary focus on exchanging data between state electronic information resources.	Cross-Border Policy Domains Implemented within specific European policy subdomains (e.g., e-Justice, e-Invoicing).	Nationwide Cross-Sector (by function) Aadhaar (ID), UPI (Payments), DigiLocker (Documents) serve specific societal functions	Nationwide Public Authority Specifically for public authorities to exchange data to eliminate citizen document requests
Key Technical Protocols	REST, SOAP, HTTP, MIME/multipart.	Not explicitly detailed in snippets, but likely identical to X-Road due to ancestry	Synchronous structured calls validated by timestamping and signing	AS4, MIME/multipart (message structure differs from X-Road)	Open APIs (though the underlying implementation is closed)	Real-time queries; newly added event-based model using Apache Kafka and WebSocket
Open Source Status	Open Source' Source code is publicly available for anyone to implement.	Proprietary Fully supported, export-focused software product suite requiring a license	Developed using proprietary software based on an original X-Road prototype	Open-Source Building Block Provides technical specifications, installable software, and services	Closed Source & Federated branding Components (Aadhaar, UPI, DigiLocker) are proprietary systems.	Not explicitly detailed, but managed as national infrastructure by the state.
Relation to X-Road	The original core technology	Developed by Cybernetica (the original developers of X-Road), based on nearly two decades of X-Road experience	Developed using proprietary software based on an original X-Road prototype	Distinct from X-Road; typically, policy-domain bound rather than a nationwide cross-sector layer	Architecturally different; closed and siloed compared to X-Road’s open and peer-to-peer model.	Shares the decentralized data management philosophy to streamline interaction.

¹¹ Cybernetica (2026), *X-Road Interoperability Services – UXP*; online available at: <https://e-estonia.com/solutions/interoperability-services/uxp/>; accessed in March 2026.

Notable Observations from the Comparative Analysis

- a. **The "X-Road Family":** UXP and Trembita are the closest systems to X-Road in architecture and design. UXP is a proprietary, export-focused version developed by the original Estonian creators, while Trembita is Ukraine's implementation based on early X-Road concepts.
- b. **The Difference in "Interoperability":** X-Road aims for a nationwide "Single Window" where *any* connected organization can securely interact with any other, public or private. EU's e-Delivery is more segmented, creating "trusted ecosystems" specifically for policy areas like health or justice.
- c. **India Stack's Unique Approach:** Unlike the European models, **India Stack** is not a single, interchangeable interoperability platform. It is a unified marketing brand for several closed, proprietary, and functionally distinct pillars (like identity or payments) that form a collective digital infrastructure.



5. Expanded & Reinforced Conceptual Model

The conceptual model below focuses on the technical aspects of the harmonization of e-government, with emphasis on how different system should be interconnected to achieve a seamless e-government regime, especially in the Nigerian digital ecosystem.

This architecture presents a reinforced and expanded model adapted from X-Road — a decentralized, secure “digital highway” designed to solve the five primary roadblocks to e-government in Nigeria.

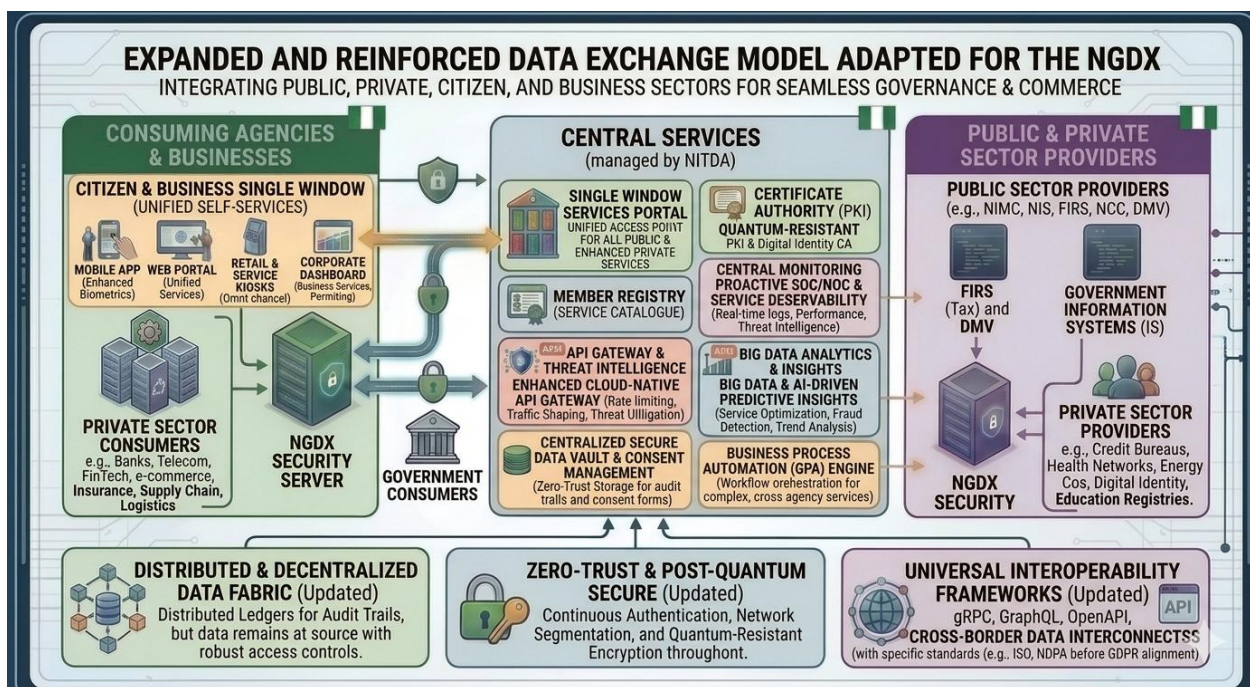


Figure 5: Conceptual Architecture of the Expanded and Reinforced Model Adapted from the X-Road Architecture

The conceptual model features three (3) core sections:

1. Consuming Agencies & Businesses (The Front-End)

This is the "demand" side of the exchange where services are delivered.

- a. **Citizen & Business Single Window:** This provides a unified interface through the Mobile App, web portals, and kiosks. It allows citizens to access government services (like passport renewal or business permits) in one place without visiting multiple portals or offices.

- b. **Private Sector Consumers:** Banks, Telcos, and FinTechs connect here. Rather than capturing new biometrics, they can use the NGDX to verify identity instantly, drastically reducing the cost of doing business.
- c. **Government Consumers:** Government agencies can also connect to harness G2G services.
- d. **NGDX Security Server:** Every participant has a dedicated security node that encrypts and signs all data requests to ensure they are authentic.

2. Central Services - Managed by NITDA (The Brain)

This hub does not store citizen data; instead, it manages the trust and traffic between agencies.

- a. **Single Window Services Portal:** The back-end engine that orchestrates complex, cross-agency services.
- b. **Centralized Consent Management:** This is a critical privacy feature. It uses **Zero-Trust storage** to track audit trails and ensure data only moves when the citizen grants permission via their app.
- c. **Quantum-Resistant PKI:** Provides the digital "keys" needed for secure communication, upgraded to protect against future cyber threats.
- d. **API Gateway & Threat Intelligence:** Manages data traffic, prevents system overloads (rate limiting), and blocks malicious attacks in real-time.

3. Public & Private Sector Providers (The Data Sources)

This is the "supply" side, where the "Source of Truth" for data lives.

- a. **Public Sector Providers:** Major custodians include the likes of NIMC (Identity), NIS (Passports), NRS (Tax), and the CBN (Financial data), etc. These agencies provide the verified data that the rest of the ecosystem consumes.
- b. **Private Sector Providers:** Includes Credit Bureaus, Health Networks, and Education Registries. This integration ensures that the exchange powers the entire economy, not just government offices.

The Foundation (The Framework)

The conceptual architecture is based on three modernized pillars:

- **Data Fabric:** A decentralized approach where data stays at the source (e.g., tax info stays at NRS, passport data stays with NIS, BVN data stays with CBN, etc.) but is accessible via secure "pointers."
- **Zero-Trust Security:** No user or agency is trusted by default. Every request requires continuous authentication and high-level encryption.
- **Universal Interoperability:** Uses modern standards like **gRPC** and **GraphQL** to act as "adapters" while encourage use of REST and SOAP standards for integration. This allows old, closed-source agency systems (the "Incompatibility" roadblock) to finally "talk" to modern apps.

Compliance: The entire system is governed by the **Nigeria Data Protection Act (NDPA)**, ensuring that all data exchange is legally compliant and protects citizen privacy.

The figure below shows a high-level functional overview of the conceptual model described above.

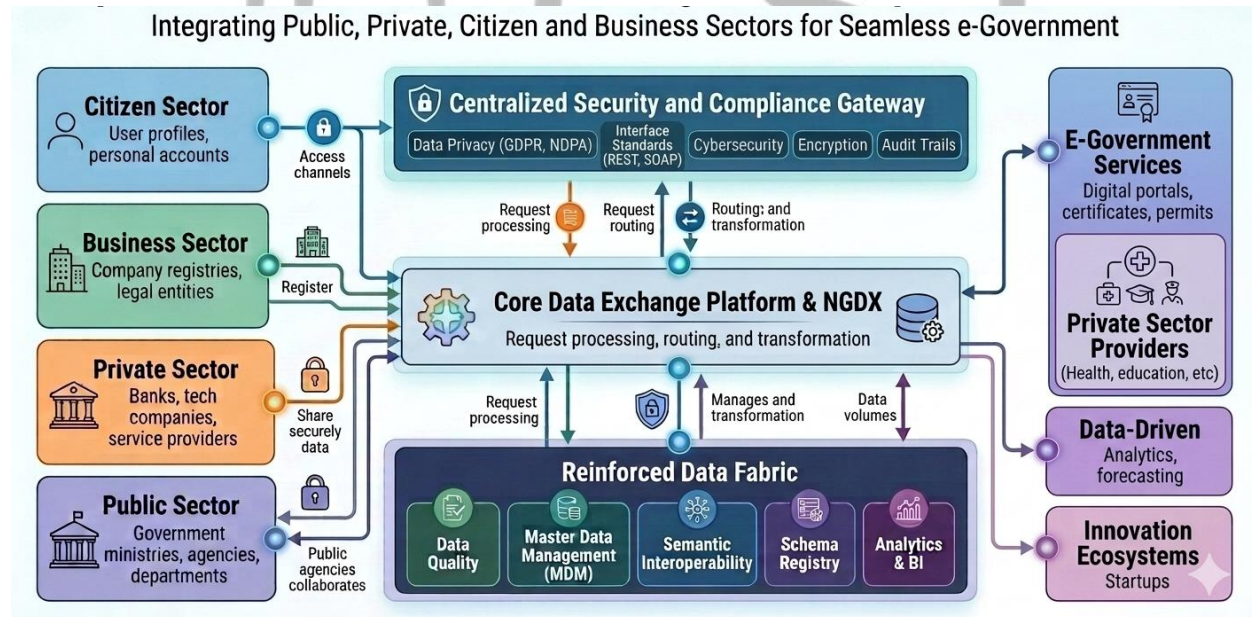


Figure 6: High-level overview of the conceptual expanded and reinforced data exchange model (Adapted from X-Road)

Alignment with the NGDX Concepts/Strategies

1. Architectural Alignment (The Hub-and-Spoke)

The "Core Data Exchange Platform & NGDX" in the centre reflects the **X-Road** model Nigeria has adopted. It doesn't store data but acts as the secure router between the four sectors on the left (the "Silos") and the services on the right.

2. Solving the "Roadblocks"

- a. **Incompatibility:** By listing **REST and SOAP** as standalone interface standards, the model accounts for both modern apps and the "closed-source" legacy systems found in many Nigerian agencies.
- b. **Data Fragmentation:** The "**Reinforced Data Fabric**" at the bottom (MDM and Semantic Interoperability) ensures that a "Name" in the NIMC database means the same thing as a "Name" in the FIRS database, allowing them to finally "talk" to each other.
- c. **Redundant Spending:** By integrating **Private Sector Providers (Health, Education)**, the model shows that the NGDX should not just be for government; it should allow private firms to "consume" verified government data instead of building their own expensive duplicate databases.

3. Legal & Security Compliance

- a. **NDPA Integration:** Placing the Nigeria Data Protection Act (NDPA) at the heart of the "Security and Compliance Gateway" ensures that all data movement is legally audited. This addresses the "Reluctance to Change" by giving agency leaders a clear, safe legal framework to follow.
- b. **Citizen-Centricity:** The "Citizen Sector" connection via Access Channels (like the NINAuth app or any other citizen-centric app) and ensures that the "Once-Only" principle is met—citizens provide data once, and the NGDX handles the rest.

Minor Distinction: While the NGDX will be technically decentralized, the "Reinforced Data Fabric" layer in the conceptual model functions as the "Interoperability Framework"—the set of rules and translators that make decentralization work without errors.

Proposed Regime versus Status Quo

Table 3: Proposed Regime versus Status Quo

Feature/Area	Current Status Quo (Q1 2026)	Conceptual Model (adapted from X-Road)
User Experience	Fragmented "Digital Islands"	"Single Window" approach
Data Storage	Massive silos/duplicate capture	Decentralized Data Fabric
Integration	Closed, proprietary systems	Universal Interoperability (APIs)
Trust Model	Manual control/Bureaucracy	Zero-Trust & NDPA Compliance

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6. Conclusion

The standardization and harmonization of e-government in Nigeria is long overdue. It should no longer be treated as a technical luxury but as a key civic responsibility of government and a fiscal necessity.

By adopting standards stipulated in the Ne-GIF and properly implementing the anticipated NGDX, Nigeria can transform its e-government regime from a fragmented bureaucracy into a lean, data-driven, fully interconnected engine for the digital economy.

The conceptual model presented in this white paper expands and reinforces the X-Road architectural strategies, with special consideration of Nigeria's peculiarities. A true single window eco-system for government services cannot be overemphasized; a regime where access to all government service, such as G2C, G2B, G2E and G2G (as well as selected private-sector-provided services) are linked, while strictly adhering to standards stipulated by the NDPA as well as industry best practices.

The conceptual model strives to eliminate architectural encumbrances for attaining a truly harmonized e-government regime in Nigeria.

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He has worked with several organizations in the design, development, deployment and management of cutting- edge enterprise systems for private and public sector businesses. He has consulted and delivered no fewer than 15 market-researches and studies on different aspects of the Nigerian Telecommunications & ICT industry.

He is currently the Executive Director of Hemingway Global Services Ltd, a reputable software company in Nigeria on a mission to provide cost effective solutions for Nigeria, Africa and beyond.

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