Case Studies on
e-Governance
in India

IPv6 Deployment at State Data Centre
West Bengal

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About the Initiative

This publication is a part of the Capacity Building initiative under the National e-Governance Plan (NeGP) by NeGD with an aim to draw out learnings from various projects implemented in various States/ UTs and sharing this knowledge, in the form of case studies, with the decision makers and implementers to benefit them, by way of knowledge creation and skill building, from these experiences during planning and implementation of various projects under NeGP.

Conceptualised and overseen by the National e-Governance Division (NeGD) of Media lab Asia/DeitY these case studies are submitted by e-Governance Practitioners from Government and Industry/Research Institutions. The cases submitted by the authors are vetted by experts from outside and within the Government for learning and reference value, relevance to future project implementers, planners and to those involved in e-governance capacity Building programs before they are recommended for publication. National Institute for Smart Government (NISG), working on behalf of this NeGD provided program management support and interacted with the authors and subject matter experts in bringing out these published case studies. It is hoped that these case studies drawn from successful and failed e-Governance projects would help practitioners to understand the real-time issues involved, typical dilemmas faced by e-Governance project implementers, and possible solutions to resolve them.

Acknowledgment

NISG sincerely thanks all the authors for documenting and sharing their rich experiences in terms of challenges and lessons learned and allowing us to publish and use these case studies in various training programs of NeGD and NISG. NISG also thanks all the external and internal experts who helped review the submitted cases, providing critical observations and for helping in articulating and presenting the case studies, both for class room use as well as a reference article.

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Abstract

This case describes how a properly managed and well coordinated activity brings upfront result even though technology stays as barrier during the implementation. As IPv4 address depletion was growing in rapid pace, Department of Information Technology & Electronics (IT&E), Government of West Bengal had accepted the challenges to reduce the dependency on private addresses and had taken a strategic decision to deploy IPv6 in the State Data Centre (SDC) to reap the benefits of secure and highly scalable IP network. This timely intervention helped the State Government to overcome the problem of scarcity of IP resource pool, it also helped the internet users in the IPv6 domain to access the State Government website. The move helped in the promotion of IPv6 addressing scheme which in turn helped in cyber security.

State IT Department had assigned this responsibility to West Bengal Electronics Industry Development Corporation Limited (WBEIDC) to implement the same on running applications of State Data Centre (SDC). It was decided to start the deployment of IPv6 at WBSDC for Banglarmukh State G2C Portal accessible using URL: http://www.banglarmukh.gov.in and then replicate the same in other running applications in SDC. Dual-stack transition plan strategy had been adopted where IPv4 co-exists with IPv6 with a preference to IPv6 during address selection in the same device. Department had faced the heat of technological impasses during and final stage of implementation. However, right kind of coordination among stakeholder and timely consulting supports assisted the department to taking right decision and meet the target in due course. Currently IT&E department is harvesting the benefits of IPv6 compliant network assets by lowering the capital cost and administrative burden in the State Data Centre. It is also helping in promotion of IPv6 which in turn is ensuring higher security in the cyber domain.

Key words

Internet Protocol Version 4 (IPv4), Internet Protocol Version 6 (Ipv6), Asia-Pacific Network information Centre (APNIC), e-Governance, Domain Name Server, Internet Service Provider, State Data Center, Dual Stack, Router, State Wide Area Network, Banglarmukh Portal.

Note to Practitioners/Instructors

This case study draws the attention to large scale deployment of IPv6 primarily in State/UTs infrastructure and avoids technical and managerial complexity. This study also reflects how a timely decision and well co-ordination among the stakeholders contribute successful project execution. Technological transition is still a major challenge for any public organization; this study tried it best to accumulate all kind of assorted and diversified challenges under one roof.

For the Practitioners:

This study recognized that State/UT government under taking IT Organizations are performing best when it comes to Bid management, bid evaluation, project management, vendor management and SLA monitoring activities. However when it comes to the technological innovation or up gradation, strategic decision making and knowledge transition, these organizations are struggling a lot to stable their footprint.

Exhaustion of Ipv4 address is imminent in near future and world is moving towards the deployment of IPv6 in rapid speed to match the wave frequency of Internet of Things. At this crucial junction, IPv6 deployment in West Bengal State Data Centre by Principal Secretary IT, was all about scaling up Internet Protocol infrastructure to meet the future demand of e-Governance across state up to block level. The said deployment was also for allowing access of the Government services to the users of IPv6. Deployment IPv6 in West Bengal State Data Centre might facilitate other State/UTs to imitate the similar decision making strategy in deploying IPv6 in their own Government Organization. This study might also facilitate different private data centre operators and corporate bodies in deploying IPv6 for their needs. This study reasserted that adoption of IPv6 needs a strong coordination within different stakeholders. Here, in West Bengal, adoption of IPv6 had coordinated effectively among different stakeholders namely Department of Information Technology (DIT&E), West Bengal Electronics Infrastructure Development Corporation, State Data Centre (SDC), Internet Service Providers and selected equipment manufacturers. Since, West Bengal was in motion to adopt cloud infrastructure at State Data Centre in providing the service delivery to citizens and different line departments, therefore, at this junction deployment of IPv6 acted as a panacea effect behind the scene.

For the Instructors:

This study is a classic example to portray when all kind of approvals were in place, resources were on-board, effective architecture had been sorted out well in-advanced and the project had the blessing from the supreme authority of the State, however due to no-availability technical infrastructure in our country, a near successful project become stalled for 3 years for the final roll out. This lead to a thought making process what are key parameters that result in successful project execution. How external parameters or non-availability of required infrastructure become sure stopper for any almost successful project. This literature could be useful in teaching effective Time management, Vendor management, Technical gap analysis and due-diligence from a large scale transition project implementation point of view.

Below mentioned list of questionnaire could spur the participants to debate, analyze and come out with relevant arguments for discussion:

a. Do you think initiation of deployment of IPv6 at West Bengal State Centre in the year 2010 was a correct decision?

b. What went wrong in the due-diligence process of IPv6 deployment?

c. If you were in the Head of Department's place, what would you have done to complete the project in time and how?

d. Do you think deployment of IPv6 at WBSDC was lacking vendor coordination?

e. Do you think West Bengal was early adopter of IPv6?

f. How was IPv6 deployment at WBSDC carried out?

g. List out your views on WBSDC IPv6 deployment

h. Do you think the Department of Information Technology, Govt. of WB was lacking the vision during the deployment of IPv6 in WBSDC?

i. Do you think non-availability of technical Infrastructure was the main concern during the deployment of the project?

Project Context

Each touch points or nodes in network such as Computer Desktop, Laptop, palmtop, Router, telecommunication devices such as Broadband, 3G, NGN, and 4G are assigned with an IP address either static or dynamic to identify and communicate with another set of devices on the network. Even though, current Internet Protocol Version 4 basically provides 2^32 approximately 4.3 Billion addresses, most of them are reserved for special purpose and not available for common public allotment. Therefore, generic allocation of IP address is failed to scale up with growing demand of IP address and become a major bottleneck for growing internet subscriptions and therefore un-intentional collision of IPs. The Internet Service Providers of the country are allocating dynamic IP addresses by porting the same to many users. Generally one IP address is being allocated to 100-200 users by an Internet Service Provider. The said practice is creating a bottleneck in detecting the actual user in the event of any cyber crime.

Based on the shortfall and depletion of IP address keeping in mind, The Government of India released the "National IPv6 Deployment Roadmap" In July-2010, which is currently the guiding document for deployment of IPv6 in India by all stakeholders in private and Government sector. During the same time, Department of Information Technology and Electronics, Govt. of West Bengal (DIT&E, GoWB) was in process to set up West Bengal State Data Centre (WBSDC) under the technical wings West Bengal Electronics Industry Development Corporation Limited (WBEIDC) and had correctly envisaged the prime need of having independent Internet Protocol (IP) resource pool with Autonomous Number (AS) from APNIC, Regional Internet Registry (RIR) in the Asia-Pacific Region. IT&E Department had critically analyzed the future demand of the State for large address space, efficient and extensible IP datagram, efficient route computation, improved host and routing discovery, easy numbering and auto configuration. Therefore, in no time department had flagged the green signal for deployment of Ipv6 in the State Data Centre.

Project Objective

State Data Centre (SDC) is one of the most important pillars in providing ICT infrastructure for various e-Governance Project across State. State Data Center basically provides a physical facility for hosting various state level e-government applications in a centralized location for functionalities such as Central Repository for Secure Data Storage, Disaster Recovery, Remote Management and Service Integration etc. Therefore, deployment of IPv6 at State Data Centre level was thought of with following objectives -

(i) Possessing independent IP resource pool without any dependency of IP address usually provided through upstream Internet Service Provider (ISP).

(ii) Making the West Bengal Government service available to the users / citizens having IPv6 address.

(iii) Provisioning of Multi-homing of IP resources & Autonomous Number (AN) with multiple upstream ISPs with provisioning of Border Gateway Protocol (BGP) advertisement at the peering ISPs.

(iv) Setting up own Domain Name Server (DNS) for resolution of IP address with domain name.

(v) Enhancing security in the Government application

(vi) Promoting IPv6 addressing scheme

Department of Information Technology and Electronics, Government of West Bengal had felt the necessity of accomplishing the above objectives and directed West Bengal Electronics Industry Development Corporation Limited (WBEIDC), Technical wings of DIT&E, Govt. of West Bengal to do the same. The journey in deployment of IPv6 in WBSDC was started since then.

Project Description

Deployment of IPv6 at WBSDC was started in the end of year 2010. At that point of time applications those were deployed in State Data Centre namely (i) Banglarmukh State G2C Portal & (ii) West Bengal e-District Pilot Application for Bankura and Jalpaiguri Pilot Districts.

With due respect to the "National IPv6 Deployment Roadmap", Department of Information Technology and Electronics, Govt. of West Bengal had decided to start deployment of IPv6 at WBSDC for Banglarmukh State G2C Portal i.e. accessible using http://www.banglarmukh.gov.in. URL Banglarmukh is an Official Portal of the Government of West Bengal, developed and hosted under the supervision of State IT Department. This particular state portal was thought of to provide a Single Windows access to the information and services of all the 68 Departments of the State and also for the services of District, Sub-division and block level by the State Government of West Bengal for the citizens and other stakeholders.

Components Structure

Banglarmukh Portal Application basically follows Model View Control (MVC) three tier architecture that is consisted of 4 Servers namely -

(i) Web layer using RHEL Apache Web Server,

(ii) Application layer using JBOSS Application Server

(iii) Database layer using MySQL RDBMS.

(iv) Alfresco as Content Management System (CMS)

Out of the 4 servers, 2 physical servers were placed in De-Militarized Zone (DMZ) and configured with Web-cum-Application Servers. These servers were also connected with

Server Load Balancer (SLB) with virtual IP provisioned in SLB. In the remaining 2 physical servers, Alfresco CMS was installed in each of the 2 servers while MySQL RDBMS was configured in one physical server.

Team of WBEIDC had configured Internet Gateway Routers (Cisco-3845) with exterior–BGP (e-BGP) for multi-homing of IPv6 pool with upstream ISPs namely Bharti Airtel & Tata Communication. Again these 2 Internet Gateway Routers connected with failover were configured with Interior-BGP (i-BGP) through loopback interface towards internal network of WBSDC. 'AS' numbers of WBSDC were peered with respective 'AS' number of upstream ISPs with BGP advertisement in the Gateway Routers provided by the upstream ISPs. Each of the upstream ISP was connected with WBSDC's Internet Gateway Router using /64 IPv6 network and Banglarmukh portal was assigned with The IPv6 Address space from main IPv6 address pool.

Implementation Strategy

Transition plan - IPv4 to IPv6 Analysis

Department of Information Technology and Electronics (IT&E) with the assistance from WBEIDC had conducted a due diligence and found following mechanisms were existed for the transition from IPv4 to IPv6.

(1) *Dual-stack* - It is a transition mechanism where both the protocols IPv4 & IPv6 co-exist with preference to IPv6 during address selection in the same devices and network**.** In Dual Stack Strategy DNS resolver returns IPv6, IPv4 and both to the targeted applications.

(2) *Tunneling techniques* - It basically avoids order dependencies when upgrading take place in hosts, routers, or regions. This is also low risk and row cost approach.

(3) *Translation techniques* - It Supports IPv6-only devices to communicate with IPv4-only devices. IPv6 nodes behind a translator get full IPv6 functionality when talking to other IPv6 nodes located anywhere. This technique gets the normal Network Address Translation functionality when talking to IPv4 devices.

As the most preferable mode of transition to IPv6 is co-existence of IPv4 with IPv6, gradual application by application upgrades to IPv6 and applications select IP version to use when initiating, based on DNS response, therefore, Dual Stack Strategy had been finalized for the transition plan. Dual Stacking avoids the complexities and pitfalls of tunneling (such as security, increased latency, and management overhead). In Dual Stacking both protocols run on the same infrastructure and as such it is easy to maintain.
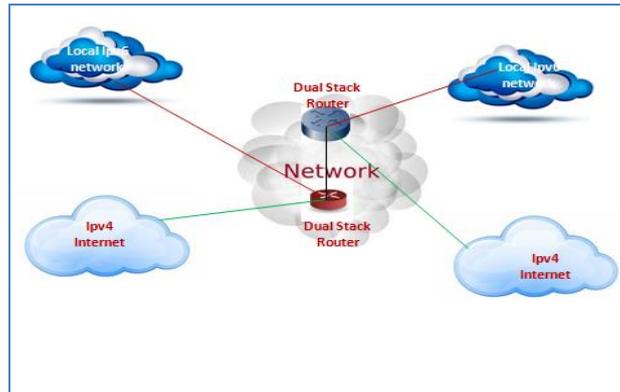
Figure 1 Dual Stack Architecture

Deployment Methodology

As IT&E department had taken a strategic decision to go ahead with dual stack technique for deployment of IPv6 for Banglarmukh web portal where IPv4 and IPv6 applications to coexist in a dual IP layer routing backbone, therefore all routers in the identified network were upgraded to dual-stack with IPv4 communication using IPv4 packets based on routes learned through running IPv4 specific routing protocol and IPv6 communication using routes learned through the IPv6 routing protocols.

APNIC database object (whois data) for this address assignment was subsequently created for both IPv6 & IPv4. Configuration in the Domain Name Server of Bharti Airtel for resolution of IP address with following domain name:

- **IPv4 -** Creation of "A" record pointed to Public IPv4 Address of Banglarmukh Portal was configured in the Authoritative Name Server (DNS Server) of Bharti Airtel.

- **IPv6 -** Creation of "AAAA" record pointed to IPv6 Address of Banglarmukh Portal was configured in the Authoritative Name Server (DNS Server) of Bharti Airtel.

- "A" & "AAAA" record for the Banglarmukh State Government portal (URL - www.banglarmukh.gov.in) were also recorded for WBSDC.

Post Deployment Status

Although National Knowledge Network (NKN) had been connected as main default link within WBSDC technical architecture, however Bharti Airtel upstream ISP is still continuing as a backup link. At this current stage, NKN is yet to advertise BGP for IPv6 pool in their gateway networking device as well as provisioning of creation of "AAAA" record for resolution of IPv6 Address with respective domain name.

IP Resources from APNIC (Regional Internet Registry) had been transferred to IRINN, a division of NIXI (National Internet Exchange of India), Govt. of India and the National Internet Registry (NIR) of India during the financial year 2013-14.

Although IPv4 pool has been provided with necessary subnets for both WBSDC network & WBSWAN Network, IPv6 pool are yet to be provided with necessary subnets for both WBSDC network & WBSWAN Network subject to readiness of NKN in due course of time. Except for the old version of system software procured during the year 2010, all the system software in WBSDC namely RHEL Operating System Ver 6.x, their respective JBOSS Application Server, Postgre SQL RDBMS or MySQL RDBMS, Microsoft Server Operating System (Windows Server 2012, MSSQL Server 2012) etc are IPv6 supported. Presently all the applications are transparent to both of IPv4 & IPv6 and thus IPv6 deployment on Dual-Stack are found much easier.

Now all the upstream ISPs (Category-A) are able to provide IPv6 from their IPv6 steady Network Operation Centre (NOC) at Kolkata and are equipped with provisioning of "AAAA" record essentially required for resolution of IPv6 Address with respective domain name. Accessibility of IPv6 for the Banglarmukh portal via Internal Network has been successfully tested.

In the year 2010 deployment of IPv6 on production environment was not ready in India; therefore testing from IPv6 Internet world was not possible in 2010, although testing under staging environment was successfully established. But now, with the availability of the public IPv6 network, accessibility of Banglarmukh portal was successfully done in 2013. IIT Kanpur (IPv6 expert group), Wipro as Data Centre Operator and Bharti Airtel as ISP had provided technical and consultation support to Department of Information Technology and Electronics, Government of West Bengal during the implementation of IPv6.

Issues and Challenges during Deployment

IPv6 deployment in WBSDC was full of challenges and deadlocks. Accessing Banglarmukh Portal from IPv6 & IPv4 Internet Cloud had encountered following major road blocks –

(i)   IT follows MVC architecture model where Web server configured with Dual Stack using both IPv4 & IPv6 addresses successfully. However each of the Application Server (JBOSS Application Server, JBoss Portal Server 2.6.7 GA) & Database Server (MySQL Database Server version 5.0) were not supported with IPv6. As such Web Server, being configured with Dual-Stack, was accessible from the IP traffic from either of IPv6 or IPv4 Internet Cloud. However communication from Web layer to Application Layer, Application Layer to Database Layer & Back to Web layer is communicated through IPv4 only. As such in case of communication from IPv6 network cloud Web server receives IPv6 address from Internet & it communicates to Internal Application & Database server on IPv4. After an in-depth technical analysis and due-diligence, project Team has identified the hardware compatibility issues and the respective hardware were procured by the department and then only Dual Stack both IPv4 & IPv6 addresses were configured successfully in the application and database servers level.

(ii)   There was a challenge to manage multiple addresses on each interface / sub-interface including a combination of IPv4 and IPv6 addresses. Technical Team of WBEIDC had ensured the reachability of Banglarmukh portal by enabling Dual Stack for the network perimeter devices namely Internet Gateway Routers (2 no.), External Firewall (each of external interface, internal interface & DMZ Interface), Server Load Balancer (Virtual IP). NATing (Network Address Translation-Public IP to Private IP & vice-versa) was provided for reachability of IPv4 addresses to the respective web server. And for IPv6, the assigned IPv6 addresses were configured in the Web server without any need of NATing.

(iii)   Since Department had identified Dual Stack Strategy for transition from IPv4 to IPv6, therefore technical team had faced challenges in dual management of the IPv4 and IPv6 routing protocols, and they configured the same with enough memory for both the IPv4 and IPv6 in routing tables.

(iv)   After successful transition of the Banglarmukh portal on the IPv6 network, testing of the same from the internet world could not be performed due to non-availability public IPv6 network in the year 2010 in India & we had to depend on the testing result from the internal network only. However on availability of the public IPv6 network in the year 2013 helped the project team to complete IPv6 network testing in the internet world successfully.

Benefits Realized

(i) Department of Information Technology & Electronics (IT&E), Government of West Bengal had realized direct investment protection on IPv6-based assets those are having a longer service life than expenditures on IPv4-only systems.

(ii) Ipv6 compliant IT assets has cut down the network administrative cost at West Bengal State data centre and also improved the manageability experience.

(iii) Successful deployment of IPv6 at the WBSDC had removed the dependency for private addressing and subsequently lowered the fixed cost associated with NAT devices.

(iv) IPv6 deployment in WBSDC infrastructure strengthens the end-to-end security and quality of service that was not available in NAT based network.

(v) Business process improvements, optimized outsourcing efficiency, and continued globalization are additional benefits which leverage IPv6-based integrated information processing systems, embedded automation capabilities, and collaborative tools such as immersive multimedia services.

(vi) With the help IPv6 compliant facility State data centre has improved the support for mobile computing and mobile IP binding devices.

(vii) Successful deployment of IPv6 for Banglarmukh has made the Government information & services available to the IPv6 users, thus enhancing the reach & also promoting IPv6. It will also encourage the usage of static IP addresses enabling higher cyber security.

Key Lessons

The journey of IPv6 deployment in State Data Centre was not as smooth as planned. Technical as well project team of WBEIDC had faced several challenges and gainsay during the initial stage of deployment. Department learned a lot of valuable lessons during the deployment process. The majority of the problems technical team faced were unanticipated.

(i) Since there were less number of upstream ISP providers those provide dual-stack support to the customer-premises equipment, therefore, department was compelled to rely only on Bharti Airtel & Tata Communications only two upstream ISPs to meet such requirement.

(ii) From the organizational perspective, department learned that IPv6 deployment potentially touches everything, and so deploying just a application, platform, a network or just a single service does not add up value to the organization. These deployment activities become a much longer duration project than initially thought of. WBEIDC has been working on this activity for 3 years and still credibly only half way to fortunate. Still, the biggest challenge is not deploying IPv6 itself, but integrating the new protocol in all management procedures and provide redundancy, reliability and security in the entire set up.

(iii) Department adopted the dual stack technique for the said implementation, which helped in the co-existence of IPv4 with IPv6 and gradual application by application upgrade to IPv6, and applications select IP version to use when initiating, based on DNS response. Dual Stacking avoids the complexities and pitfalls of tunneling (such as security, increased latency, and management overhead). In Dual Stacking both protocols run on the same infrastructure and as such it is easy to maintain.

(iv) Department had faced countless application level challenges when no proxy, no web cache communication protocol, no web server and no application server were supporting IPv6 and aligning the vendor to get all the components supported for IPv6 was a nightmare. Therefore, it advises the organization should conduct a network device audit including routers, switches and firewalls, with the help of vendors before starting the deployment process. Then organization shall creates an IPv6 compliant device list for available hardware and software and thereafter directs the network administrator to run basic test on particular IPv6 device to confirm that the software application to run on the organization network bring positive result.

It has being a long time IPv6 was considered and equally ignored as a "future requirement." However, the scenario has changed drastically, and as IPv4 address space is depleted, it is time to take this deployment of Ipv6 earnestly with a positive note across State and UTs in India.

Methodology adopted for Case Writing

Face to face Interview and formal discussion based Case writing methodology has been adopted in writing the case study.

Instruments Used –

- A set well-defined Questionnaire was designed to conduct formal interviews.

- The mode of Interview – Online emailing and Personal visits.

Entire set of information was collected either through Primary and Secondary sources, consisting of Project Officials and Project Director of the Department of Information Technology and Electronics, Government of West Bengal and WBEIDC. Case writing team had made couple of visit to West Bengal Electronics Development Corporation (WBEIDC) office and interviewed the project manager of the implementation and maintenance team. Interview process was fully in structured mode and scheduled for half an hour to 1 hour for each interviewee. Inter-Observer method has been induced at measuring how well two or more respondents VIEW the same phenomenon. State Designated Agency (SDA) responsible for WBSDC has actively supported during data and information collection process. State and central Government websites, white paper, peer reviewed journals, blogs were acted as a secondary source of information during shaping, structuring and formulating this case study.

LIST OF ACRONYMS

S. No.	Acronym	Description
1	APNIC	Asia-Pacific Network Information Centre
2	AS	Autonomous System
3	BGP	Border Gateway Protocol
4	DIT&E	Department of Information Technology & Electronics
5	DNS	Domain Name Server
6	e-BGP	Exterior Border Gateway Protocol
7	GoWB	Government of West Bengal
8	i-BGP	Interior Border Gateway Protocol
9	ICT	Information and Communication Technology
10	IP	Internet Protocol
11	IPv4	Internet Protocol Version 4
12	IPv6	Internet Protocol Version 6
13	IRINN	Indian Registry for Internet Names and Numbers
14	ISP	Internet Service Provider
15	MMP	Mission Mode Project
16	MVC	Model View Controller
17	NAT	Network Address Translation
18	NGN	Next Generation Network
19	NKN	National Knowledge Network
20	NIXI	National Internet Exchange of India
21	RIR	Regional Internet Registry
22	SDA	State Designated Agency
23	SDC	State Data Centre
24	SHQ	State Head Quarter
25	SLB	Server Load Balancer
26	TCL	Tool Command Language
27	WB	West Bengal
28	WBEIDC	West Bengal Electronics Industry Development Corporation
29	WBSDC	West Bengal State Data Centre
30	WBSWAN	West Bengal State Wide Area Network

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