# IPv4 to IPv6 Network Transformation

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**Abstract**

*The target of 4 to 6 Transformation is a research field and business process related to the network infrastructures migration from IPv4 to IPv6. Currently only about 8.6% of the IPv4 address space is free therefore that process could be considered inevitable. The migration to the new protocol could be pretty expensive for the network operators and extremely disruptive for the end customers. The Project aims to deliver an open framework capable of handling the migration process. The framework consists of three major components – Business Transformation Logic (BTL), Network Inventory and Service Transformation. Each of the components extends the Fulfillment, Assurance and Billing (FAB) Model and could be easily integrated with the current OSS systems*

## 1. Introduction

This paper describes the proposal for intelligent IPv4 to IPv6 network transformation framework. The prospect is developed under the 4to6TRANS project. The project aims to deliver scientific and technical quality in the area of Future Internet to all kinds of network players throughout Europe. Currently IPv6 is matured enough and is already widely supported by the network industry vendors and software manufacturers [2],[3]. Most of the Operation Systems, Browsers, Email Clients, Web and DNS Servers already support IPv6. The share of free IPv4 address space is getting smaller and it is expected the network providers to migrate their current services and subscribers to the new protocol [12]. Nevertheless, still a real migration to the new protocol does not occur. It will be costly and extremely disruptive, which is the major factor impeding its real start. Another reason is that currently, there are no tools, software, commercial and open platform able to handle similar migration.

## 2. Concepts and Objectives

Facing that problem, realizing that similar network migration task being extremely complex the project authors propose an open 4to6TRANS framework to be created, having the power, flexibility and ability to model the current services, to speak with the network devices and to follow certain business logic during the transformation process. The framework architecture consists of several Application Programmable Interfaces build on technologies beyond the current state of art.

The framework is supposed to give the possibility to the Network Operators to perform the transition in controlled and automated fashion. The final project output will be of great help to a big number of Internet Service Providers, Cable, Telecoms and Mobile operators to optimize the transition process and to reduce the loss of service periods in their networks. From the other perspective the end users (most of the population of European Union) won't experience a significant loss of service during that service transition periods.

Fig. 1 presents a typical IPv4 Internet Service Provider network with some common network nodes and services [1]. We have an MPLS backbone and several service clouds build around it. The project focuses on service transformation of ISP residential clients, but also on Inter ISP BGP peering and corporate data services. The framework will be robust and flexible enough to handle easily the communication with great diversity of network devices as routers, switches, radius/diameter servers, Policy Control Points, xDSL modems, WiMax base stations and IPTV platforms.

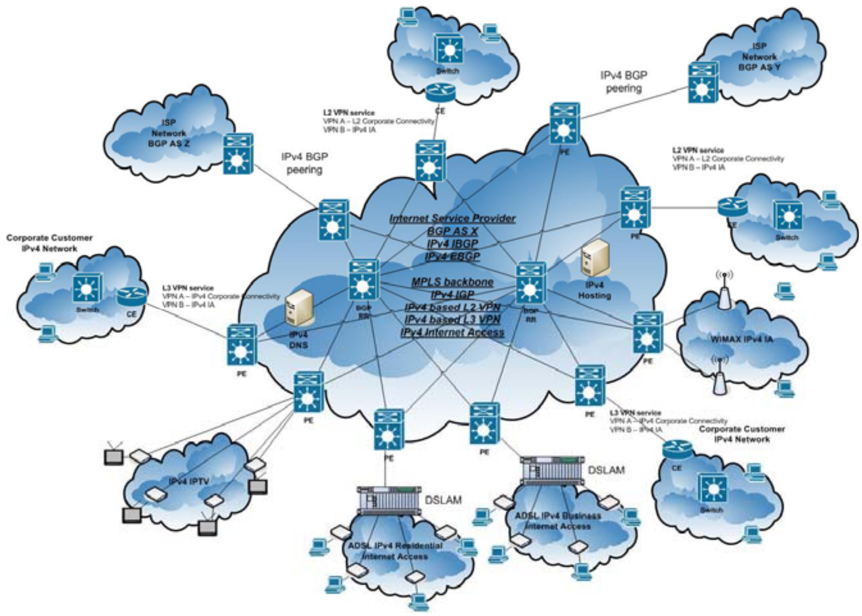


*Figure 1. IPv4 ISP Network*

As a final result the framework will be able to transform the described IPv4 based services and platform to IPv6 one, if the last is supported on that platform. In case the protocol is not supported, a transition methodology will be proposed and configured on the devices of the network operator. The final result is fully or partially migrated IPv6 based network (fig.2.).

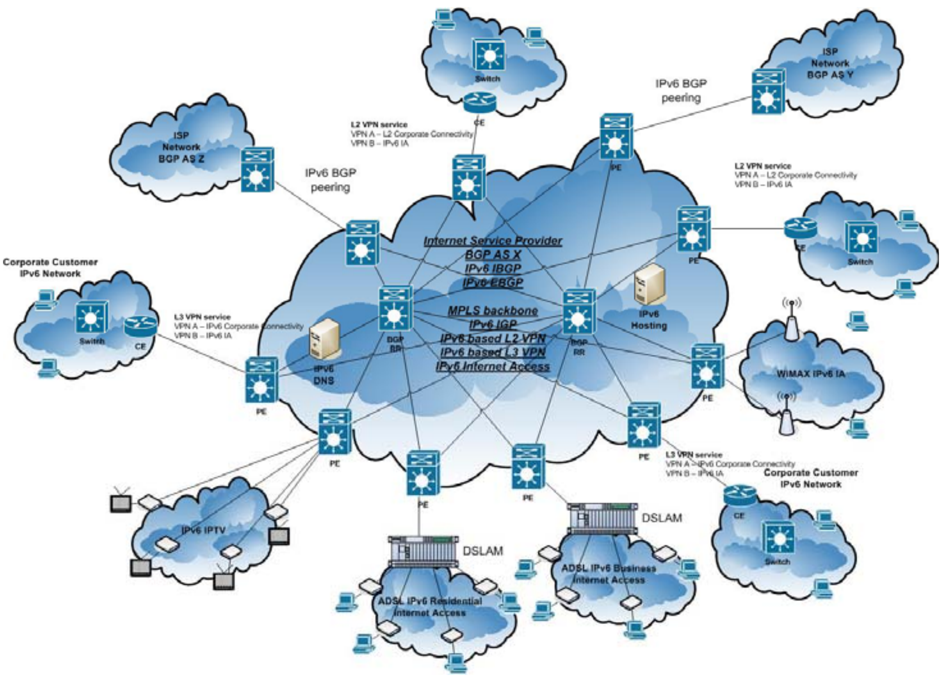


*Figure 2 . IPv6 ISP Network*

For the purpose a number of open application programmable interfaces (API), able to model the transformation process, are to be specified and created.

The first stage is the specification of the framework's API. The API's can be split in three major groups:

- Business Transformation Logic (BTL)
- Network Inventory
- Service Transformation

The output of that phase is:

- Detailed framework architecture specification
- Network Inventory APIs software specification
- BTL APIs software specification
- Service Transformation APIs software specification

The second phase is APIs creation. The APIs are to be realized in the state of the art technologies like PL/SQL, J2EE, JFC SWING, ORACLE and XSL. The output of that phase is:

- Network Inventory APIs source code
- BTL APIs software source code
- Service Transformation APIs source code

The third part of the project is on testing and integrating the framework with real network devices. The present IPv6 enabled laboratory in Sofia, Bulgaria (sponsored and established by the EU) is going to be used as a lab environment. The current lab setup is going to be extended for the purpose of the project. One of the project objectives is to test the API's against different network vendors. Therefore, the current lab is to be upgraded and some more network devices are to be added to the current infrastructure.

Several service provider architectures will be simulated with most of the common ISP services. The services planned to be tested are Internet BGP Peering, DSL Internet access, MPLS L2 VPNs and MPLS L3 VPNs.

The goals achieved in the last phase are:

- Perform Inter vendor Network Discovery
- Perform Inter vendor Device/Service Upload
- Model certain service business logic through workflow creation
- Transform IPv4 services and subscribers to an IPv6 following certain business logic.

The output is:

- Network Discovery documentation
- Network Upload documentation
- Prove of Concept Tests documentation

## 3. State of the Art

### 3.1. Current Standards and Specifications

The 4TO6TRANS Project follows the general concepts of the OSS (Operations Support Systems) based on the ITU-T recommendations and best practices proposed by the TM forum. Fig. 3 presents the FAB (Fulfillment, Assurance and Billing) Model, a part of the E-tom model architecture [11].

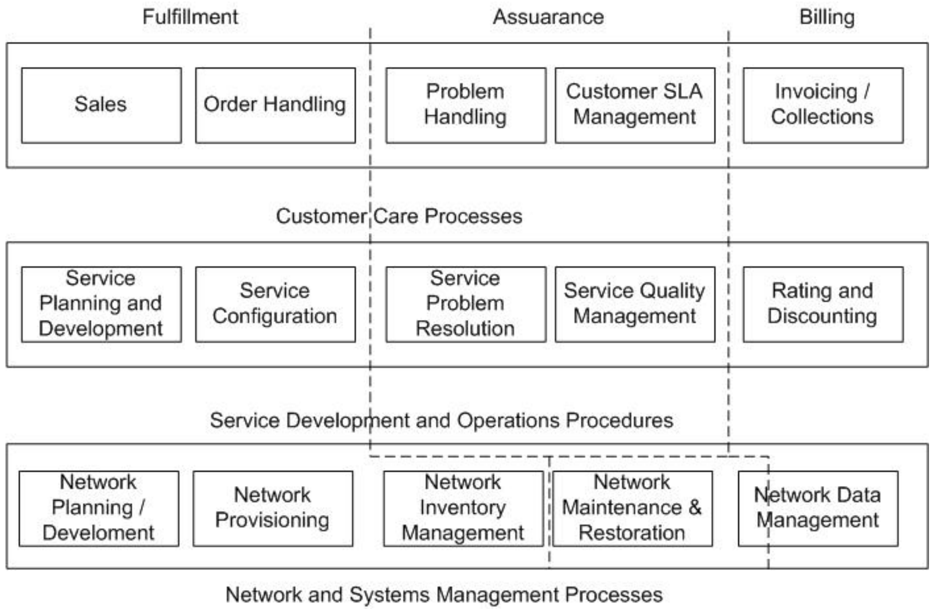


*Figure 3. FAB Model*

The IPv4 to IPv6 transformation framework extends the Fulfillment part of the FAB model. The BTL will be added to the current "Service Planning and Development" and "Service Configuration' components. The current "Network Inventory" will be extended with the objects needed for the service transformation. The Network Provisioning will be extended with the "Service Transformation API".

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### 3.2. Other Similar Solutions

Currently there are many OSS systems following the recommendations of the TM forum and delivering some of the components of the fulfillment branch of the FAB model. These platforms could be classified as platforms produced by Network Equipment Vendors that support only their equipment and independent OSS vendors that support the equipment of many vendors. Among the first group are companies as Cisco [13], Eriksson [19], Nokia [20], Siemens [21], Juniper [17], Huawei [18] and many other network and telecom equipment vendors. In the second group are companies as Amdocs[14], Telcordia [15], Sigma Systems [16] and others.

From the perspective of 4 to 6 service and device configuration transformation, considering the fact that most of the Network and Telecom operators have services realized on the equipment of many vendors, we believe that the first group of OSS systems will not handle the process properly. Some of the companies, part of the second group of OSS software vendors are producing solutions that could be considered as a state of the art in the OSS business field. Unfortunately, none of these companies are focusing on the IPv4 to IPv6 transformation process. The last platforms neither have an automated device upload, nor an automated discovery process. As a rule, once the network resources are entered into a similar system they could not be changed easily.

These solutions may have network inventories, workflow managers and service activations, but none of them could handle the complexity of similar service transformation.

## 4. Progress beyond the State of Art

The 4to6TRANS Project aims to deliver a software framework and practical guidelines for smooth and controlled migration to IPv6 with minimal loss of service. All Internet Service Providers, Telecom, Cable or Mobile operators are expected to migrate to IPv6. Each one of them will benefit greatly from the proposed service transformation framework. Since that migration will directly reflect to each and every customer of those organizations we may conclude that most of the population of the European Union using Internet Services, Mobile Services or data connectivity will benefit indirectly from the project output. Currently, there is no product or platform, having the capacity to handle so complex migration task. This section will identify the progress beyond the state of art that will be achieved through the successful completion of the 4to6TRANS Project.

### 4.1 Solution Architecture

The solution architecture consists of several layers. The upper layer provides an interface for northbound integration with external systems and interfaces [9]. That layer provides the framework with the Service Transformation Orders. On the next layer two of the main framework components reside (the BTL and the Network/Service and Subscriber Inventory). The second layer components are able to communicate between each other through an open APIs and also with the upper and the lower layers. All the service transformation policies and rules are included in it. The layer contains the logic behind the transformation process and all the data for the network subject of transformation. The lowest layer main purpose is to process the request from the upper layer and to the network. It will handle different communication protocols with different kinds of network elements.

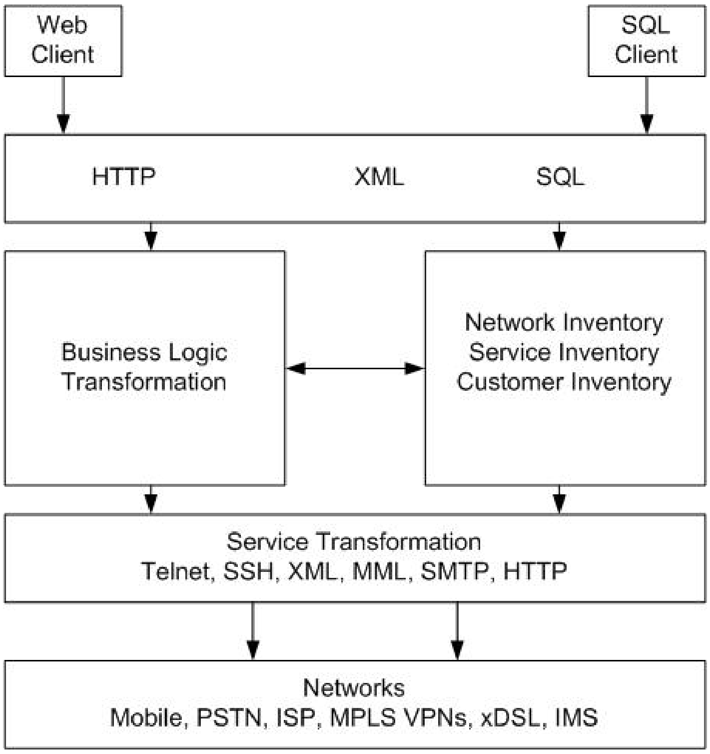



*Figure 4. Solution Architecture*

### 4.2 Device Discovery

One of the main goals of the project is to have an automated upload of the device configurations into the network inventory. Such process will save large amounts of time to the network providers prior to the transformation phase. Therefore, network discovery algorithm has to be implemented in the system. An initial IP address and a stop rule must be entered as an initial input in the system, prior to the discovery start. For example, if MPLS P router is discovered, the discovery process will stop. Then it has to analyze the outcome of certain commands and MIBs in order to determine the device neighbors. Once the neighbors are identified, the process algorithm will move to them, it will identify their neighbors and continue the discovery process. Once a certain device having been discovered, the Network Inventory will perform a full upload of it. The discovery algorithm has to stop in case the device is already discovered or in case the stop rule is resolved.

### 4.3 Device Upload

Devices upload aims to model router logical service model into the network inventory. Network inventory has to be populated only with a subset of the device configuration that will be needed by the BTL for a successful transformation. For the purpose, the transformation platform has to communicate with the device through a set of standard or proprietary protocols. Such protocols could be CLI (Telnet, SSH), SNMP or MML. Clearly, there will be a preference for SNMP MIB browsing rather then the rest of the protocols.

The upload might be triggered for a group of devices (e.g. upon a network discovery completion) or for an individual one (e.g. manual request). Once triggered the upload process will systematically interrogate the individual devices to obtain the necessary data to achieve the representation in Inventory.

There are a number of discrepancies in the way the devices return the requested information, even across different models/platforms belonging to the same manufacturer.  Therefore, the information gathering process will need to be resilient enough to deal with different response formats.

Once the information is gathered from the network device, it will be processed and the relevant data modeled in Inventory. Figure 5 displays a high-level view of the process.

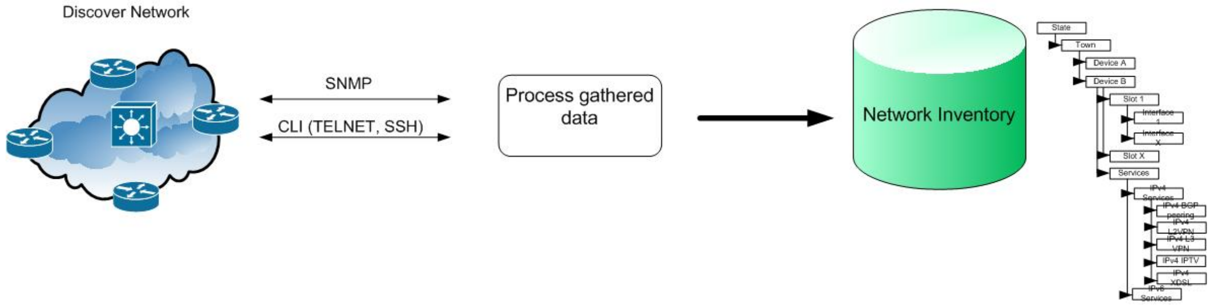



*Figure 5. Upload Process Overview*

### 4.4 Network/Service Inventory

Once the upload process is finished, the network inventory is supposed to contain a logical model of the device. A simple logical model is presented on fig. 6.

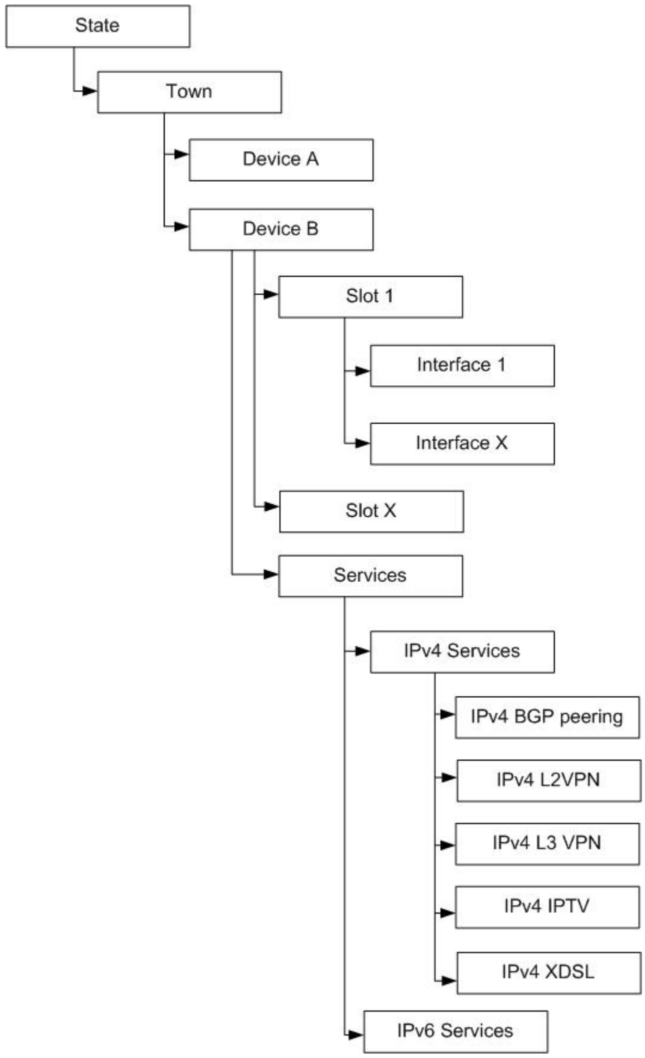



*Figure 6.. Network/Service Inventory*

## 4.5 Service Automation

Once the inventory is populated with the logical model of the network, its devices and services, the information will be used for modeling the transformation process algorithm. Service automation will be achieved through the Business Transform Logic. That part of the solution has to control the transformation process from IPv4 to IPv6. The first main goal of the Business Transform Logic is to be able to model a certain transformation algorithm. An example for a simple transformation algorithm is given on fig. 7.

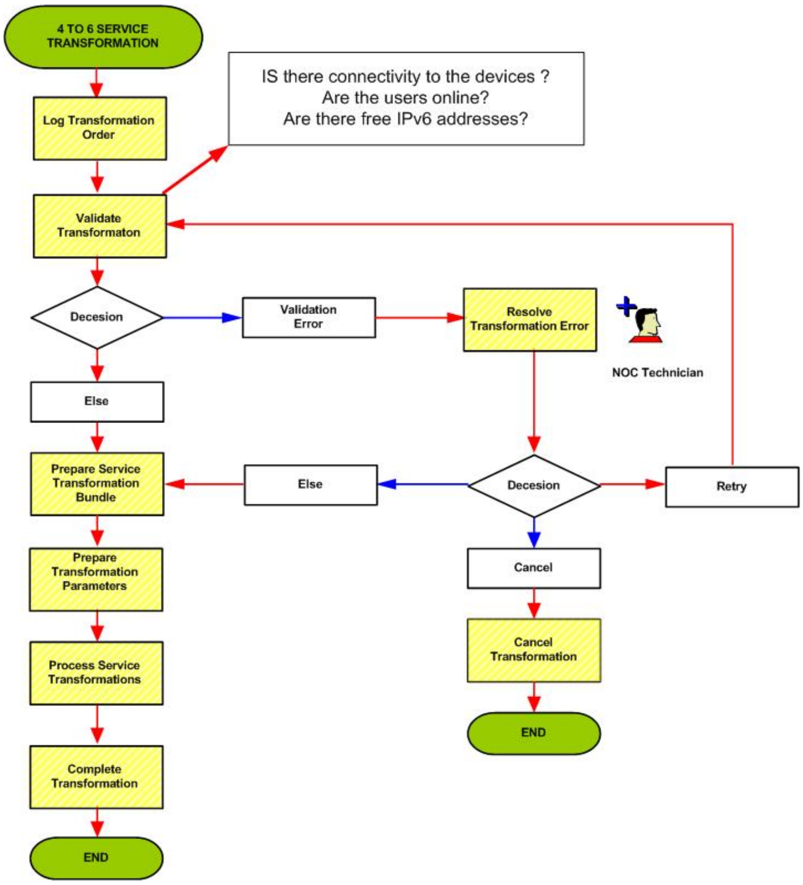
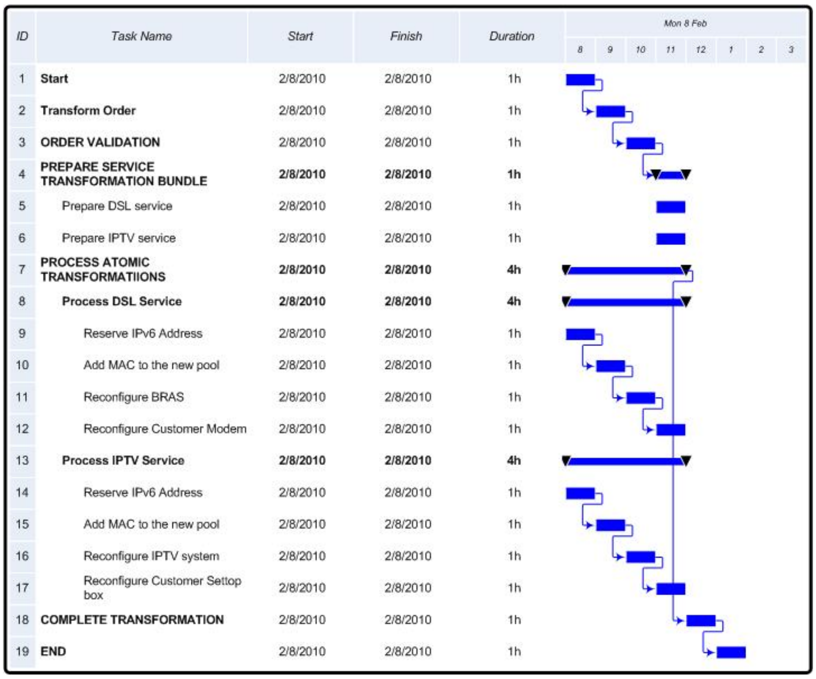



*Figure 7. An Example for Service Transformation Process/Algorithm*

Only the senior ISP administrators and consultants have to be able to model service transformation algorithms. The rest of the users have to be able to process the different transformation tasks from a GUI interface. The platform will give an opportunity to the operators to see the transformation process as a GANT chart (Fig. 8).



| ID | Task Name | Start | Finish | Duration |
|---|---|---|---|---|
| 1 | **Start** | 2/8/2010 | 2/8/2010 | 1h |
| 2 | **Transform Order** | 2/8/2010 | 2/8/2010 | 1h |
| 3 | **ORDER VALIDATION** | 2/8/2010 | 2/8/2010 | 1h |
| 4 | **PREPARE SERVICE TRANSFORMATION BUNDLE** | **2/8/2010** | **2/8/2010** | **1h** |
| 5 | Prepare DSL service | 2/8/2010 | 2/8/2010 | 1h |
| 6 | Prepare IPTV service | 2/8/2010 | 2/8/2010 | 1h |
| 7 | **PROCESS ATOMIC TRANSFORMATIIONS** | **2/8/2010** | **2/8/2010** | **4h** |
| 8 | **Process DSL Service** | **2/8/2010** | **2/8/2010** | **4h** |
| 9 | Reserve IPv6 Address | 2/8/2010 | 2/8/2010 | 1h |
| 10 | Add MAC to the new pool | 2/8/2010 | 2/8/2010 | 1h |
| 11 | Reconfigure BRAS | 2/8/2010 | 2/8/2010 | 1h |
| 12 | Reconfigure Customer Modem | 2/8/2010 | 2/8/2010 | 1h |
| 13 | **Process IPTV Service** | **2/8/2010** | **2/8/2010** | **4h** |
| 14 | Reserve IPv6 Address | 2/8/2010 | 2/8/2010 | 1h |
| 15 | Add MAC to the new pool | 2/8/2010 | 2/8/2010 | 1h |
| 16 | Reconfigure IPTV system | 2/8/2010 | 2/8/2010 | 1h |
| 17 | Reconfigure Customer Settop box | 2/8/2010 | 2/8/2010 | 1h |
| 18 | **COMPLETE TRANSFORMATION** | 2/8/2010 | 2/8/2010 | 1h |
| 19 | **END** | 2/8/2010 | 2/8/2010 | 1h |



*Figure 8. Service Transformation GANT Chart*

The different tasks may be placed in different work queues and thus the transformation process may be manual, automatic or semi automatic. For example, the most of the tasks (fig. 8) may be placed in an automatic queue, but the "resolve transformation error" may be placed in a manual queue. Then the operator may resolve the error manually and process the task. If there is a successful transformation the network inventory has to be populated with the IPv6 service branch.

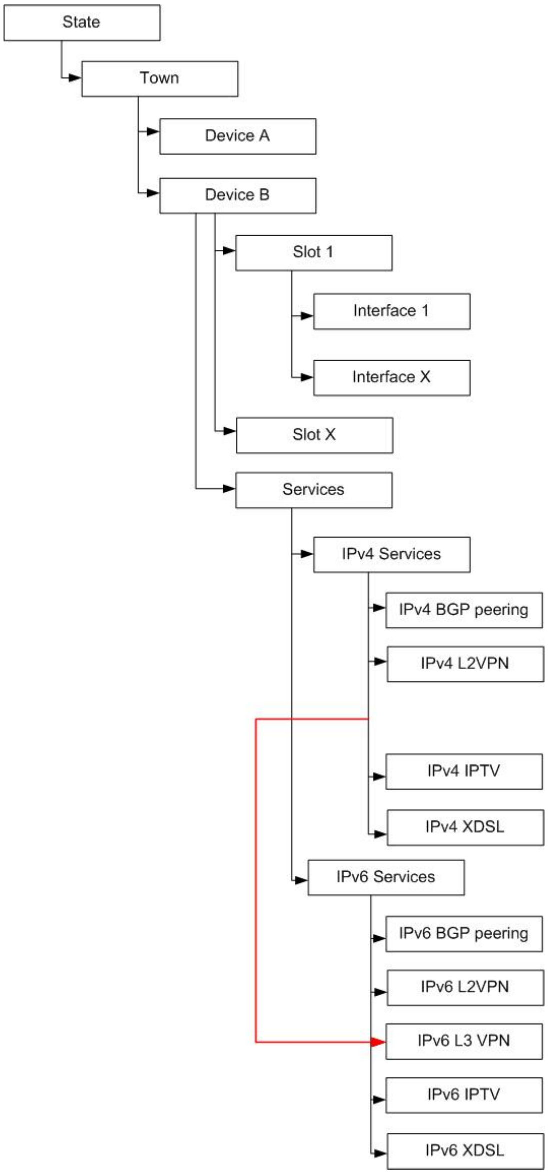



*Figure 9. Network Inventory Object Tree after a Successful Service Transformation*

As a final result of successful service transformation the service is moved from the IPv4 Services branch into the IPv6 Services branch.

## 5. Conclusion

In this paper we made a presentation and an observation of the principal ideas of the 4to6TRANS Project. It aims to deliver a framework for IPv4 to IPv6 migration and also to fulfill scientific gaps in the current OSS solutions. The framework consists of several major components: Business Transform Logic (BTL), Network Inventory and Service Transformation. Each of these components extends the state of the art products in its business field and delivers a scientific and practical value beyond the current state of art.

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