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DEPLOYMENT PLAN FOR NEXT GENERATION NETWORKS

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Abstract: Service convergence for digitization of the content over internet and packet based information transport, above the economies of scale, rapid rise in requirement of network for flexible service delivery, reduction of capital and operating costs. Changes in telecom policy and regulation, ever increasing competition have been key factors which lead to the evolution of Next Generation Networks (NGN).Telecom service providers worldwide are migrating their network architecture towards for deployment of new next generation networks to meet the market competitive edge. The NGN is aimed to provide a multitude of services over a single integrated network infrastructure, rather than multiple segments and overlay networks which existed before. It is also expected that the PSTN will co-exist with next generation networks in the foreseeable future.This paper addresses the challenges related to the planning of the next generation networks and a reference architecture enabling integrated end-to-end planning of next generation network.

I. INTRODUCTION

THIS This paper discusses the service convergence and the convergence of multiple segmented networks and technology in the evolution of IP-based next generation networks. The packet based next generation networks provide telecommunication service using transport technologies in which service related function is independent of underlying transport technologies.

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The market for information and communications technology is currently undergoing a structural change. They were planned and implemented for the transfer of specific data such as telephone calls or pure data packages. The recent growth in competition, new requirements for the market and technological developments have fundamentally changed the traditional attitudes of the telecommunications industry. The present industry is characterized by the rapid growth of broadband connections, the convergence processes of various network technologies and the emergence of a uniform IP standard for individual and mass communications. Thus, planning such a network for deployment from legacy network to the next generation network pose significant challenges to the network planners. The planning is to be done in such way, that network is not over-built. To ensure that there is no unnecessary capital expense for infrastructure. However, it should not be under-built as it could impact the customer service and experience. A generic architectural solution is proposed in this paper that enables end-to-end planning of the next generation networks which provides integrated planning of various domains and layers. Support of legacy network is also addressed in the proposed architectural solution. The paper also discusses how the challenges and issues faced in the planning of the next generation networks are addressed in the proposed solution. The paper is organized as follows: in section I, we discuss the factor responsible for development of NGN. Section II , we discuss service and network convergence and describe next generation networks architecture covering various domains and layers. Section III outlines generic planning process and challenges in planning next generation network. Section IV outlines the need for integrated network planning. Section V provides a detailed view of solution architecture, its different components, and how it meets the challenges of integrated planning of next generation networks. This section also Discuss regarding the benefits customer gain from deployment of NGN. Finally we conclude the paper in section VI.

II. NEED FOR NEXT GENERATION NETWORK TO SUFFICE CURRENT MARKET SCENARIO

The heterogeneity of the infrastructure, the growing competition and the falling call sales can be regarded at present as the primary threats to the telecommunications industry. Established network operators are finding themselves forced to rethink their business models and to convert their infrastructure to a fully IP-based platform – the Next Generation Network. The overall aim is to reduce costs and to create new sources of income, as shown in Figure 1

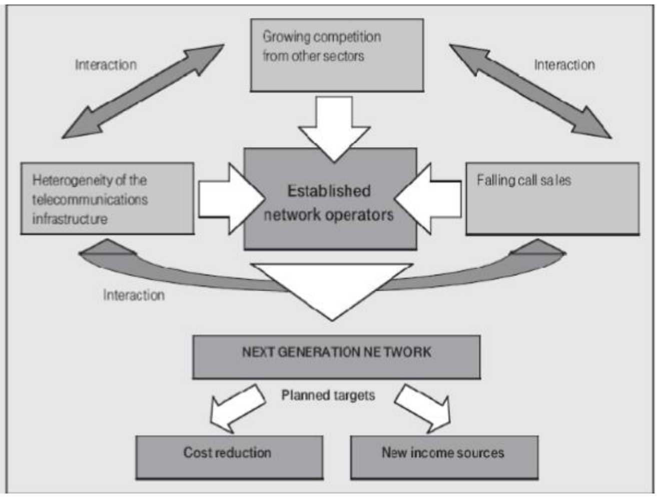

Figure 1 Causes for development of NGN.

A Heterogeneity of the Telecommunications Infrastructure

The modern telecommunications networks consist of various wired and wireless technologies. Satellite and mobile phone networks such as GSM/UMTS, POTS, Wireless local networks such as wireless LAN and Bluetooth networks, Fixed networks such as Ethernet and FOC networks. In the traditional network, infrastructure, the introduction of new services and applications can be an expensive process. For instance, a concept for launching innovative services can take between 6 and 18 months. The process requires high staffing costs. Many functionalities in the network have to be configured manually in order to implement new features. Moreover, the variety of networks and the heterogeneous subscriber end devices make the provision of infrastructure-independent services more difficult. As a result, the services can only be used via specific networks and appropriately adjusted end devices such as fixednetwork phones, cellphones, televisions, etc. The growing number of services has led to an increase in the platforms needed to provide them, which in turn has increased the complexity of the overall infrastructure. The problems of interoperability between the various systems are becoming more serious, and this growing complexity is also placing greater demands on staff. Maintaining these platforms involves high annual operating costs for the network operators. Established network operators often maintain 15 to 20 different platforms with hundreds of central switches, which inevitably leads to extremely high staffing costs.

B. Growing Competition from Other Sectors

As a rule, networks such as mobile telephony, data networks and fixed networks are dominated by different suppliers. Providing services and products in these networks requires an interaction of various, complementary elements. In this sense, it is necessary to differentiate between value-added levels such as hardware, network access, applications and content. The increased use of IP-based networks for the provision of applications and services is allowing the development of new, digital value-added chains. Visions of the gradual convergence of fixed networks, mobile telephony and the Internet are having a crucial influence on the development of this sector. In the future market, the widest possible range of roles will be available for different players. This will particularly threaten the leading position of the established network operators on the telecommunications market. Apart from the fixed-network and cellphone operators, companies from other sectors will also establish themselves in future on this convergent market. Portal suppliers with strong brand names and powerful financial backing – including Google, MSN, eBay and Yahoo – are planning to penetrate the voice and infrastructure business. They will also be joined by cable network operators and companies that provide media content, such as Microsoft (see Figure 2)

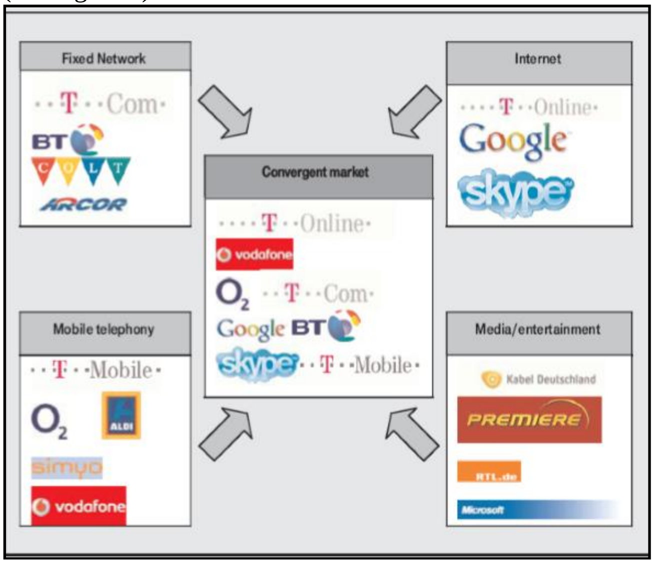

Figure 2. Possible convergences of the markets

This convergence is therefore producing virtually inevitable conflicts and incompatibilities. Technologies and market forces are colliding with each other. The market participants are crowding each other out and defending their positions strongly. In the course of this convergence, the value of the network business will gradually decrease and the service range will make a much larger contribution to end-customer sales. Traditional network operators will have to rethink their business model and also position themselves much more strongly on the upper levels of the value-added chain

C. Falling Call Sales

The increasing competition due to the liberalization of the markets and the arrival of market participants from other sectors are causing great concern to the operators of former state monopolies. The classic telephone business, known as a Public Switched Telephone Network (PSTN), is particularly unsatisfactory. The golden age of the high-margin business with revenue in the billions based on classical phone calls is clearly over. Figure 3 shows the estimated development of the global number of telephone minutes since 1990 end some predictions for market trends till 2015. In spite of the current fall in fixed-network minutes, a strong growth in the total of telephone minutes is to be expected. Experts see particularly strong potential in the use of the Internet Protocol for phone calls. This so-called Voice over IP (VoIP) is possible with all IP-based networks.

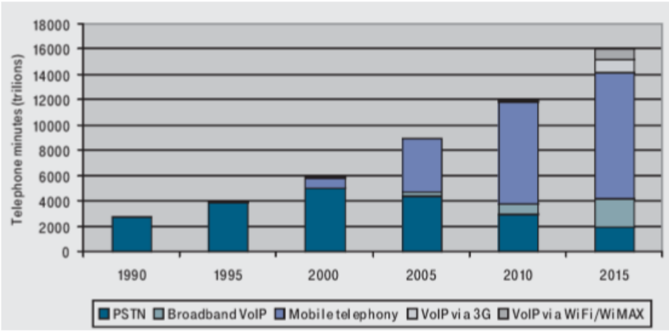

Figure 3 Development of global telephone market.

While fixed-network calls are stagnating, mobile telephony is enjoying strong growth. Fixed network operators are afraid of widespread cancellations of fixed-network connections. Increasing losses on the domestic fixed-network market are therefore forcing the operators to develop new strategies to secure their future and to boost their profitability. No further growth can be expected through call sales alone

III. NEXT GENERATION NETWORK ARCHITECTURE – CONVERGENCE, DOMAINS AND LAYERS

A. Service presently available in market and Network Convergence

Although Voice, Video, Data have typically been the predominant services used today, there have been many applications under these broad categories of services that need different quality of service (QoS) and user experience. For example, as part of video service, broadcast video and video conferencing need different QoS. Similarly though web browsing and net-meeting are both data services, each application expects different QoS. Typically, different services have been supported by different end devices, for example voice service by telephone, video services by TV, and data services via computer.

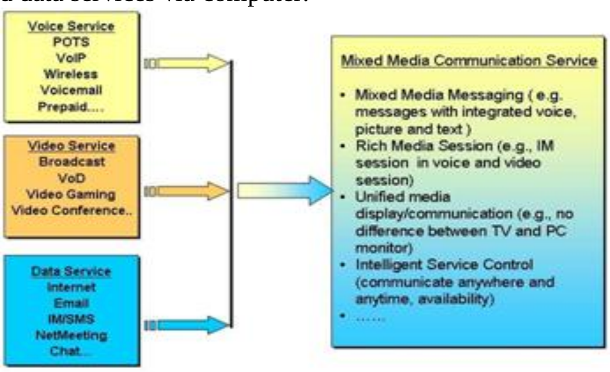

Figure 4 Service Converged

However, there is a convergence of these services in the sense that all these different services and application can be accessed and used via a single device (e.g., PDA) by end user rather than having multiple devices to support each type of services and/or application as in the past. Thus, all different services are converging to rich multi-media services in which the user can access those services any time from any place using a single device. Fig. 4 above depicts the service convergence that has already happened and is also evolving. In the past, the network has evolved and grown in a segmented way and overlay models was standard. For example the PSTN network was separate from the data network. SS7 network is also designed as a separate network supporting signaling for PSTN network. As new generation of services grew and technology (e.g., ATM/FR, Optical Ethernet) evolved, new networks were deployed but mostly worked in a segmented and overlay model. It has led to complexity and high cost in terms of building, operating and maintaining multiple segmented networks using different technologies.

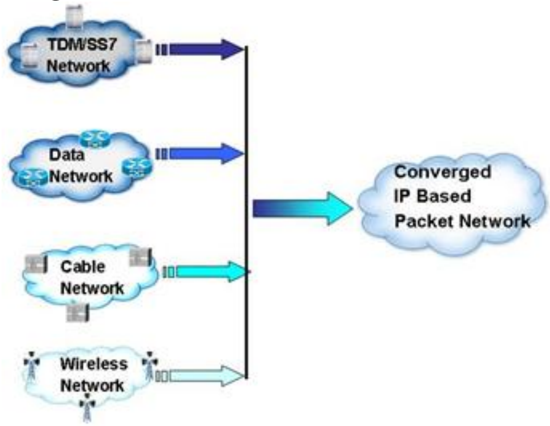

Figure 5 Converged Network

The service convergence, evolution of technology, OPEX (Operational Expense) and CAPEX (Capital Expense) savings have led to evolution of packet based converged network as shown in figure 2. Different existing and emerging service/applications can be supported over a single

B. Next Generation Networks Architecture, Domains and Layers

Fig. 6 below provides an overview of reference NGN architecture model based Y.2012 recommendation [1]. It is a two layer model structured with service stratum and transport stratum.

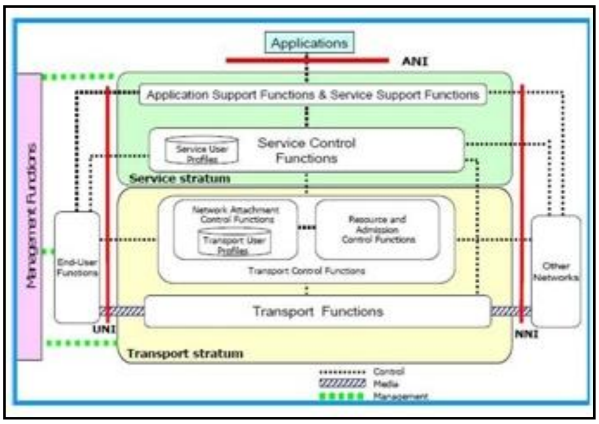

Fig. 6 ITU-T Y.2012 NGN Architecture Model

The service stratum primarily covers application/service support and session control, where as transport stratum provides flexible transport technology covering access and core network which enable service delivery in a manner agnostic to service type and its characteristics. Fig. 6 provides an overview of a generic next generation networks architecture with emphasis and extension of transport stratum of ITU-T architecture model along with reference to existing legacy network (e.g., ATM/FR) based on typical deployment scenario by service providers. The next generation network is a converged network supporting various technology domains that span from the home/premises to the core network. The various application domains of the next generation network can be organized into:

Home/Enterprise Network: This is the network used by end users such as residential homes, multi-tenant dwelling units (MDU) or business entities. Typically enterprise/business units use LAN internally and use Customer Premise Equipment (CPE) routers that connect to the service provider's network. The residential homes are typically connected via Home Gateway (HGW) to the provider network. Nowadays HGW supports variety of home networking technologies such as POTS, FOC, Ethernet, and wireless. Typically Home/Enterprise network is not within service provider's operational network domain.

Access Network: The access network domain is part of the next generation network that provides the last mile access to home/enterprise network. The access network domain uses various technologies ranging from xDSL (Digital Subscriber Loop), FTTx (including Fiber to the Home (FTTH), Fiber to the Node (FTTN) etc.), Hybrid Coax Fiber (HFC) to existing and evolving wireless technology.

Aggregation Network: The aggregation network domain provides traffic aggregation from the access network and routes the same to the core network. ATM and Frame Relay network is still widely deployed in this domain and declining. Carrier Ethernet has made significant progress in this domain due many factors such as its low cost and simplicity [2].

Core Network: There has been significant innovation and technological growth in IP in recent years and MPLS based IP network is rapidly getting deployed in core network domain. The scalability, resiliency and ease of supporting new services on a single core infrastructure are very attractive. It also provides a cost effective alternative to multiple overlay networks. In addition, IP/MPLS based core infrastructure provides easy interoperability with various existing layer 2 technologies and protocols such as Ethernet, ATM and Frame Relay [3].

In addition to the network domains described above, the next generation networks architecture supports various protocol and media layers. As depicted in Fig. 6, the next generation network is expected to support all existing, as well as various evolving services over IP (layer 3). It also supports various layer 2 protocols and services such as Ethernet, ATM, and Frame Relay. MPLS LSP (Label Switched Path) which provides logical connectivity similar to ATM PVC can be considered as layer 2.

The upper layer protocols are carried over transport layer (layer 1), which could include SONET/SDH, DWDM and ASON (Automatically Switched Optical Network) technology.

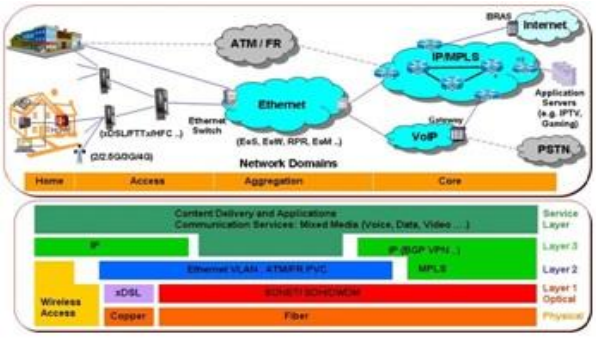

Fig. 7 Next Generation Network Architecture

As next generation network is getting deployed, it is also expected that the legacy network will also co-exist in near future.

IV. NETWORK PLANNING PROCESS AND CHALLENGES

A. Network Planning Process

An overview of the network planning process is depicted in Fig. 9. The key inputs to a network planning system are:

Physical Inventory of Network Topology: The planning system must have a view of the existing (as-built) physical topology of the network that needs to be planned and/or augmented based on forecasted traffic demand. This could include various Network Elements (NEs) at different locations/sites, its configuration, and physical media interconnecting various sites and NEs. This information can be discovered and/or retrieved from a physical inventory system that may exist as part of OSS (Operation Support Systems) in NOC (Network Operation Center) of a service provider.

Logical Inventory of Network Topology: In addition to physical topology information, the planning system requires the logical topology information of the as-built network. This includes various logical connectivity/path such as MPLS LSP, routing information etc. Logical topology information is critical, as the traffic routing is dependent on the logical connectivity/routed paths. Again, the logical topology of the network can be discovered and/or retrieved from different network management systems.

Demand Forecast: One of the major inputs for strategic planning of the network, is forecasted traffic demand. This includes various services that need to be supported in near future as well as their traffic profile. The market needs to be captured based on customer demographic including its growth/decline over planning horizon, as different types of customers may subscribe to different types of services. Customer types and population densities could vary by location, thus it is essential that the planning system should be able to capture the market demand along with its geographic location. The population density of a customer type could be distributed over a geographic region, or there could be aggregated traffic demand at a specific location such as an enterprise customer and multi-dwelling units. Typically this information comes from sales/marketing and/or Business Support Systems (BSS)

Business Rules and Guidelines: The planning of the network is also dependant on various business rules and potential predetermined technology guidelines. The business rules could be broad, for example all access networks will use FTTH, or it could be specific, such as limiting use of specific configuration of equipment from a particular vendor that needs to be deployed in a particular region. The planning system shall be able to capture these rules and appropriately plan the network.

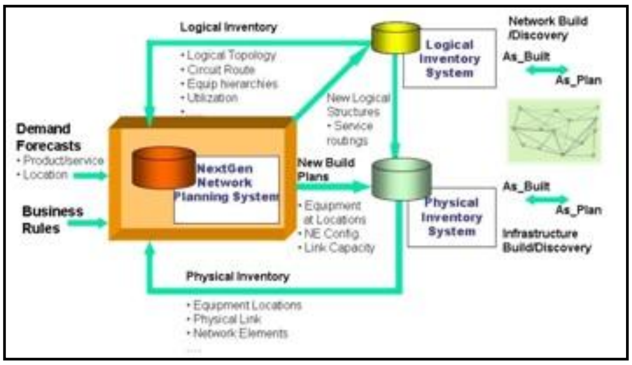

Figure 9 Network Planning Process

The planning system produces the information that enables building of planned network based on existing network topology/infrastructure and forecasted traffic demand, in compliance with the business rules and guidelines. The planned network when built, becomes part of as-built network. Thus the state of as-planned network changes to as-built network when the planned network is built and deployed. Various aspects of network planning for evolving network architecture are described in [4].

B. Next Generation Networks Planning Challenges

Service convergence and evolution of next generation network as a single converged network covering many technology domains and layers, and its interdependency, poses significant planning challenges. The key challenges are outlines as below:

- Capturing market service demand and forecast in a accurate and consistent manner for various locations/regions and traffic distribution across the network
- Capturing the existing network infrastructure, both physical and logical topology and provisioned services
- Planning of different network domains spanning access, aggregation and core, as well as entire network in a seamless manner
- Supporting multiple technologies used in the different domains as well as in the entire network
- Support of multivendor equipments in and across technology domains
- Evaluating technology options available to build the network in a cost optimal way
- Addressing long term, short term, and even on-demand
- capacity planning of the network to meet operational scenarios
- Supporting different business rules and guidelines during planning process
- Inter domain planning taking multiple layers into account.
- Failure scenario analysis across network domains and layers
- Traffic sensitivity analysis across domains, and its impact on entire network.

V. NEED FOR INTEGRATED NETWORK PLANNING SOLUTION

The various challenges and requirements as outline in previous section leads to the need of an integrated network planning solution for next generation networks. The service stratum with different services/application in ITU-T NGN architecture model is carried over the transport stratum. Since the next generation network is a single converged network, traffic demand in one domain has traffic load impact on other domains. Thus each domain cannot just be planned in an independent manner. Determination of traffic load impact from one network domain to other, and seamless flow of traffic load across multiple domains needs an integrated network planning solution. The next generation networks support various layers in each domain and across the domains. It requires that a planning system provides effective planning and visualization of services over the multiple layers and the associated physical layers across multiple domains. The failure analysis has inter-domain and inter-layer impact. For example fiber cut at physical layer could impact the traffic at IP layer (layer 3). Determining the impact of failures across domains and layers, and analysis of failure scenarios and mitigation strategies, needs an integrated planning solution approach. As legacy network is expected to co-exist along with next generation networks, the migration plan of services from legacy network has to be handled in a coordinated and integrated fashion.

VI. AN ARCHITECTURAL SOLUTION FOR INTEGRATED NETWORK PLANNING

A solution framework for planning of next generation network is described in paper [5]. The Fig. 10 below provides overall architectural view in support of integrated planning of next generation network. In this paper we provide brief context of the solution architecture, and mainly focus on details of integrated planning aspects in meeting the challenges and issues, as outlined in previous sections. The referenced architecture [5] is component based, in which various components and sub-components can work in a plug and play manner. The following section provides a brief description of various components of the solution architecture. Then we focus on details of the integrated planning component enabling end-to-end seamless planning of next generation networks, which is specific contribution of this paper.

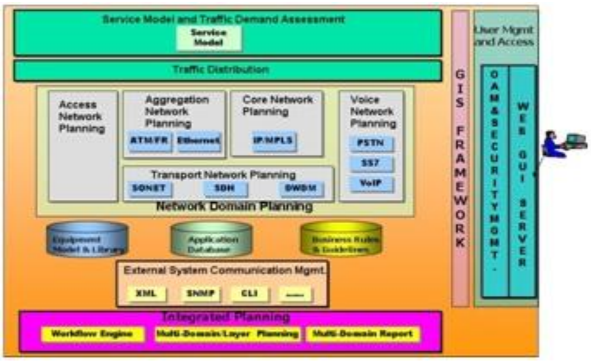

Figure 10 Network planning

A. Brief Overview of the Solution Architecture Components

Service Model and Traffic Demand Assessment: This component provides mechanism to capture various services as well as the traffic profiles associated with different service types. The traffic profile shall be dependent on service type, and could include parameters such as average bandwidth, peak bandwidth, and QoS characteristics. The key functionality of this component is to compute effective bandwidth needed, based on the service characteristics, which shall be used to determine capacity need in next generation network. There are various framework and models for computation of effective bandwidth [6]. Traffic Distribution: The traffic distribution component would enable the traffic distribution computation across various domains, based on the network architecture and service characteristics. This component can use various well known traffic distribution models [7, 8]. Network Domain Planning: This component has different sub-components covering planning of each network domain. The Access Network Planning sub-component enables planning of next generation access network. It shall cover various technology options such as ADSL, ADSL 2+, VDSL, FTTx, HFC etc. The Aggregation Network Planning sub-component covers the planning of the aggregation network. It further contains two subcomponents: ATM/FR – for legacy ATM/Frame Relay network planning, and Ethernet – for carrier Ethernet network planning. The Core Network Planning sub-component helps plan core IP/MPLS network. It supports planning of traffic engineered LSP using various routing mechanism (e.g. Constraint Shortest Path First – CSPF) to meet QoS requirement. It also supports various protection mechanisms [9] for reliability of the core IP/MPLS network. The Transport Network Planning sub-component provides planning functionality at layer 1. It supports various optical transport technologies such as SONET, SDH, DWDM, and, increasingly ASON (Automatically Switched Optical Networks). The Voice Network Planning sub-component has three subcomponents: PSTN – for planning of legacy PSTN network with sizing of switch and traffic trunks, SS7 – for planning and reliability analysis of SS7 network that support signaling for PSTN network, and VoIP for planning of bearer VoIP and signaling network supporting various signaling protocols such as SIP and H.323.

Equipment Model and Library, Application Database, & Business Rules and Guidelines: The equipment Model and Library component supports a generic equipment model and framework for capturing configuration of different multi-vendor equipments in various network domains. The Application Database provides common data repository for various planning components and sub-components. It also provides persistent data repository for logical and physical topology of the network that needs to be planned. The Business Rules and Guidelines component provides a framework for supporting business rules and guidelines in the planning process.

External System Communication Management: This component provides basic communication interface support for communicating with externals systems such as OSS, inventory systems and network, from where the planning system can get information on physical and logical topology of the network. This component has different subcomponents like XML interface to communicate with OSS, Simple Network Management Protocol (SNMP), and Command Line Interface (CLI) that interface and interact with NEs in different network domains and enables the discovery of physical and logical topology of the network.

Geographical Information System (GIS) Framework: This component enables planning applications and other components to use geo-spatial information and provide planner with GIS based visualization of existing and planned network.

User Management: The user management includes OAM and Security Management that supports user administration, authentication, authorization, auditing, and secured communication etc. [10] for user. The Web GUI Server provides web-based access to planning system from client workstation.

B. Integrated Planning of Next Generation Network

Integrated Planning is the key component that enables integrated planning of the next generation network. This component has three main sub-components:

- Workflow Engine: This sub-component enables seamless information flow across multiple domains and layers. For example, it provides the traffic demand from multiple access domains to aggregation domain, and distributes traffic load in associated aggregation domain using traffic distribution component. It also retrieves information in the application database component to determine the dependency and inter-connectivity between various access domains and interconnected aggregation domain. In a very similar fashion it enables the seamless data flow between aggregation domains and core domain. Workflow engine also enables the data and information flow across different layers based on the information in application database component. The rules of the workflow engine that enables right data/information flow across the domain and layers are user configurable, and primarily driven by network architecture and interconnectivity of different domains.

- Multi-domain/Layer Planning: Components in each planning domain enables the planning of the specific domain. The Multi-domain/Layer Planning component is the key module that gives the interworking between various domains using workflow engine component. This component helps planning of multiple domains/layers, or entire network. By interaction with each domain components, it enables planning of multiple components in an integrated way. For example when the traffic demand is distributed across various domains via workflow engine and traffic distribution components, it enables planning of all associated domains in a unified way. Similarly it enables the unified planning across multiple layers. This component essentially enables integrated network planning of whole network (end-to-end) with support of capability such as global traffic sensitivity analysis, inter-domain and inter-layer failure analysis.
- Multi-domain Reporting: This sub-component enables producing planning reports for end-to-end planning of the next generation networks by interacting with specific domain planning components. The reports could be inter layer network plan in a domain, for example in an aggregation network, it could include build plan for Ethernet network along with underlying transport network. The reports could be inter domain and inter layer, as well as covering entire next generation network. Primarily reports include List of Materials (LoM) and Bill of Materials (BoM) across multiple domains, layers and/or entire network for a planning horizon under consideration.

The solution architecture meets next generation planning and challenges as outlined in section III and IV. The market and service demand capture is supported by Service Model and Traffic Demand Assessment component. External Communication Management component enables discovery of physical and logical topology of existing network either from OSSS, or directly from network, as required based on the deployment scenario. Various domain planning sub-components enable planning of different network domains spanning access, aggregation and core, including support of Multiple technologies, multi-vendor equipment, technology option evaluation, strategic/tactical/on-demand capacity planning in each domain. Business Rules and Guidelines component enable enforcement of specific business rule and technology guidelines during the planning process. The Integrated Planning component supports integrated network planning requirements that include: inter domain traffic flow, dependency and sensitivity analysis across different domains and layers including failure and reliability analysis

C. Benefits for the customers

The interaction of man and technology plays a crucial role in the introduction of previously unknown technologies on the market. The essential prerequisite for the success of innovative information and communications systems is their acceptance by the customers. Characteristics such as the perceived system benefit and the user-friendliness of the technology are extremely important. One of the desired goals of NGN is the possibility of adapting the services better to the needs of the customer. Due to the future restriction to a single end device – equipped with a wide range of applications and services – the customer will in many ways enjoy improvements on the current situation. At present, customers expect applications for telephony and conferences. This sort of application should be independent of the network type. Customers also want to have more control over their services. That includes the ability to easily change or add services, regardless of location. Above all, though, the primary focus is on the wish to reduce costs and so there is great interest in package prices. In the past, network operators sold specific end devices and services for every type of telecommunications network, e.g. text messaging (SMS) via mobile telephony or e-mail via the Internet. Due to the integration of telephony, messaging, video communications and other multimedia information services both in fixed and mobile networks, it will probably be possible to offer the customer greater convenience in future. It should be expected that the greater control of the customer over his own services, the omnipresence of the network and flexible billing methods will prove to be extremely advantageous.

• Control: Current processes require a personal communication with the customer for the activation or deactivation of services. NGNs should give the customer more control over his own service portfolio through online interfaces, such as webpages, for instance. In this way, network operators and service providers will save processing costs and the services will be provided for the customer in real time.

• Omnipresent: The term “presence” is frequently used in the mobile world and describes the personalization of services. Personalization characterizes the individual customizing of services to a specific user, in contrast to uniform standard services (e.g. the analog telephone service). Moreover, the services should be provided regardless of the location. The network must detect with which end device the user is currently connected to the net and where he is currently located. His subscribed services are then provided to him regardless of his location.

• Flexible billing methods: It will be possible for network operators to charge for scaled services via the NGN. For instance, the customer could be provided with only “besteffort” broadband services for surfing on the Web, but he could also use a much higher bandwidth with QoS parameters on request, to guarantee the required quality.

Additional costs may be incurred when downloading a movie, which are automatically integrated in the customer’s bill. It is therefore to be expected that the perceived benefits – especially because of increasing flexibility, mobility and convenience – will grow as convergent services become more widespread. The increasing personalization of the services will also significantly influence the perceived benefits. The information and services provided will be customized to suit each customer's personal context. However, it remains to be seen to what extent applications and services can be used with a single end device without any particular technical knowledge. Real growth spurts can be expected especially once a clear, tangible added value is perceptible without any particular complexities and also the majority of the market segments are being addressed. The user-friendliness is a decisive factor particularly for older people. The variety of services must not be too heavily technical, complex or unclear. In the end, the successful interaction between man and technology often proves to be much more difficult than anticipated.

VII. CONCLUSION

This paper provides an overview of market trends on service and network convergence, and reference next generation networks architecture focused on transport stratum. Various domains and layers of next generation networks have been discussed. The evolution and deployment of next generation network poses multiple challenges for network planners and mangers, and integrated network planning is essential to deploy and operate next generation networks in a cost effective way. This paper focuses on integrated planning aspect of reference solution architecture to meet multitude of network planning challenges, thus enabling cost optimal planning and deployment of next generation networks.

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