

Conceptual Frameworks for Interconnection of Heterogeneous Networks

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Abstract

The paper will present conceptual frameworks for interconnection of heterogeneous networks in techno-business prospective. The framework aims to provide seamless interoperation between heterogeneous networks belonging to different operators or technology domains. Ambient Networks is providing such capabilities for further openness of interfaces that would bring new business opportunities for new players in global market. The concept of network composition and mobility between heterogeneous technologies will bring mass changes in network business. The paper will discuss interconnection architecture of ambient networks, business model along with its regulatory aspects.

1 Introduction

Ever since the advancement of telecommunications is taking place, mobile technologies remained the fastest growing in last decade. The advent of day to day new technologies brought new challenges for people in techno-business sector. On one hand the creative destruction horrifies vendors and operators, at the same time it brought new business perspective for future competition. Numerous networks with diverse services are offered to users highlighting the concept of Value Network. The number of different radio access technologies and operators has been increasing over the past few years. The incompatibilities and inconsistencies between network functionalities [1] limit the potential usefulness of the available networks and infrastructure. End users are increasingly not just owners of a terminal or PC; they own and effectively operate a network of devices at their homes and offices, and around the body.

The Wireless World Initiative (WWI) is a set of 5 coordinated research projects – MobiLife, SPICE, Ambient Networks, WINNER and E2R –spanning the communications stack from future wireless air interfaces, through ambient networking, adaptive radio systems, service provisioning frameworks and distributed application architecture. There are some other projects as well addressing the interconnectivity of heterogeneous networks. The concept of bridging between different heterogeneous networks is introduced to create more business prospects. It aims to provide

end-to-end communication that is generally hurdled by seamless bridging between networks and hiding complexities of these networks from each other. **Ambient Network** [8] is investigating how heterogeneous network configurations and diverse mobile user systems and applications with specific mobility requirements can be integrated into an internetworking architecture, which supports flexible plug & play and easy deployable network services at the same time. The scope of the paper will target ambient network, as one of the method for interconnections of heterogeneous networks.

2 Ambient Network Architecture

Ambient network [6] aims to provide a domain-structured end-to-end view for the network control. In this way, an ambient network is expected to embrace the heterogeneity arising from the different network control technologies such that it appears homogeneous to the potential users of network services. The vision is to allow agreement for cooperation between networks on demand, transparent, and without the need of pre configuration or offline negotiation between network operators. The idea of being operator is drastically changed over the years, as every one can be owner of their own networks at homes and offices.

Figure 1[6]shows the common, distributed control space encapsulates both legacy and future internetworking infrastructures and showing example functionality such as support for overlay networks or network context. This new common control plane functionality can be integrated as an add-on to existing to legacy networks.

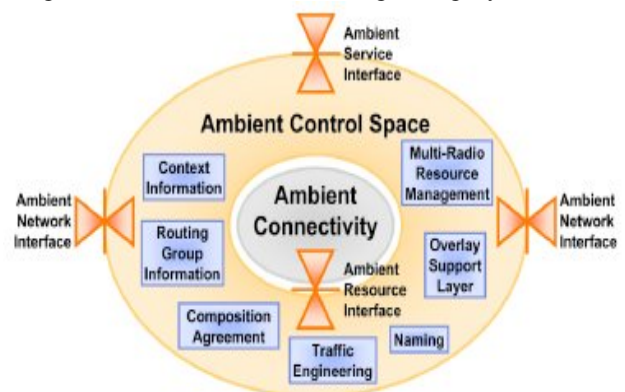


Figure 1: AN modularization and interface

2.1 Composition

Network composition [5] takes a central part in the Ambient Networks project. It means integration of different networks. Current systems provide this facility only for data plane. However network composition allows dynamic and instantaneous interoperation in control plane. By instantaneous interoperability we mean global availability of user services through different network technologies. Or in other words one user of a particular network service provider can be facilitated seamlessly by any other network technology provider. Composition can result in one single AN comprising of several ANs managing all logical and physical resources contributed by each constituent AN. This main AN has its own ACS (Figure 1) controlling all its resources, and communicates to the outside with its own identifier and via its own ANI.

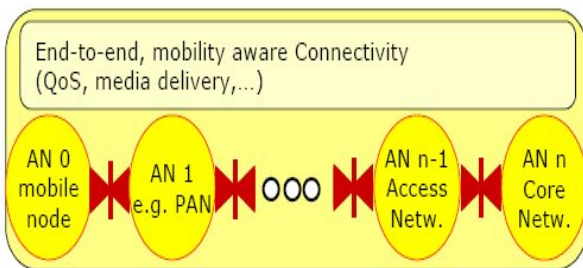


Figure 2: Composition in AN

Composition can result into one or more AN that is influenced by policies and trust aspects between the network operators. Depending on the agreement resources belonging to constituent ANs might stay under the control of each individual AN.

Another new aspect that composition brings to network cooperation is the automation of this process. Automation means automatic and seamless availability of networks. This requires pre-negotiated agreements between different network operators. The network cooperation can be between all kinds of networks, from individual devices (Bluetooth or Zigbee etc) to cellular networks.

2.2 Mobility

AN focuses on integrated mobility [8] concepts. The traditional concept of roaming is extended to a wider framework, i.e., providing roaming between different network technologies. There are four main ideas in AN mobility, handover and locator management, reachability management, moving network support, and triggering.

Handover and locator management takes care of handover procedure in ambient environment. **Reachability management** ensures that the corresponding node is always built to locate AN node. **Moving network support** handles routing groups along with its formation, maintenance and management.

Triggering is to collect and identify various events from different sources and process them according to the policies. Figure 3[7] refers to all the above mentioned concepts in AN mobile management. It should be however noted that in order to facilitate these concepts inter-process communication is needed.

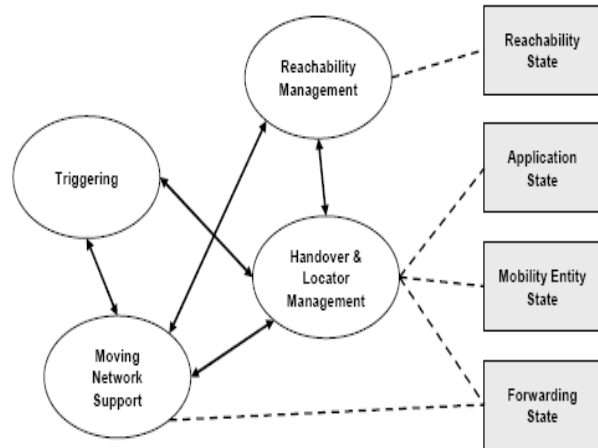


Figure 3: Mobility Management in AN.

2.3 Heterogeneity

AN is an attractive business idea as it supports multiple networks of different operators and technologies, which results in availability of a wide range of services at a low cost to the customer. However realization of such a solution is challenging from technical viewpoint. Heterogeneity addresses the issue of hiding complexities of one network from the other both on application and application developer level by providing the same or interoperable link technologies, IP versions, media formats and user contexts.

For example, consider a media context in which the concern is to accommodate differences between contexts, while still providing an end-to-end service. In order to do so data may have to be manipulated at context borders. This can be done through introduction of the *Interstitial Function* (IF) [3], whose purpose is to allow data to pass between two adjoining contexts. Contemporary examples of IFs include Network Address Translator (NAT) boxes, signaling gateways, and Border Gateway Protocol BGP routers. IFs may explicitly be used to bridge dissimilar transport networks (e.g. IPv4 onto ATM).

3 Business Model

ANs project focuses on new networking technologies but the strategic goals are very much driven by business considerations, as can be understood by the objectives in the project definition. "The Ambient Networks project

aims at an innovative, industrially exploitable mobile network solution, which enables the composition of networks across business and technology boundaries in order to stimulate new business developments and growth in the wireless domain”[4].

We have already mentioned briefly the technical aspects of composition now our objective is to explore its business side. To give a clear picture we divide this section into two further subsections. In network composition process, we will elaborate how the composition will come into business reality. Where as, in the market actors, we will further elaborate the key players involved and their possible relationships effecting the business in value networks.

3.1 Network Composition Process

Network Composition as described earlier can support many different cases, e.g. Cellular network (2G,3G etc) interconnecting to Personal Area Network or residential network connected to sensor network or a moving network with a cellular network. User wants to pay for “continuous connectivity” that eventually represents value networks. The composition process on business level consists of the five phases; Media Sense, Discovery & Advertisement, Security & Internetworking Establishment, Composition Agreement Negotiation and Composition Agreement Realization.

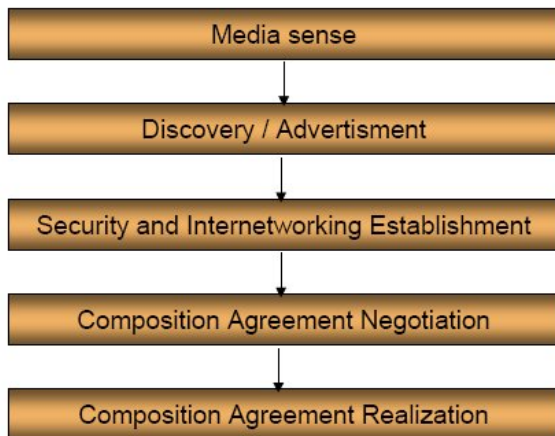


Figure 3: Phases of Composition Process

Figure 3[7] shows the process of composition in sequence, which can be further described as [7],

Media Sense is to sense a medium that enables communication with a neighboring node, another network or device. The “sensing” also includes the case of discovering a link to a remote AN.

Discovery & Advertisement leads to selection phase; selecting a candidate AN for composition. It also allows

discovering other ANs identifiers, resources, capabilities and (networks) services.

Security and Internetworking Connectivity phase is needed after discovery phase as any two ANs need to establish interconnectivity taking care of security aspects through cryptography or third party authentication.

Composition Agreement (CA) Negotiation phase includes negotiations on terms and conditions. Composition Agreement negotiation aims to agree on technical and business. CA template could include the following items; ID, Service description, QoS requirements/guarantees, Legal issues and financial issues, monitoring and performance reporting, problem and failure reporting.

Composition Agreement Realization concludes Network composition. It includes configuration of networks according to Composition Agreement negotiated earlier.

3.2 Market Actors

Business Model Roles will explain the presence of different players, which will be involved to interconnect heterogeneous networks. As the Ambient Network aims to create market opportunities and increase competition and cooperation, several new key players can enter in role with established giants of telecom market.

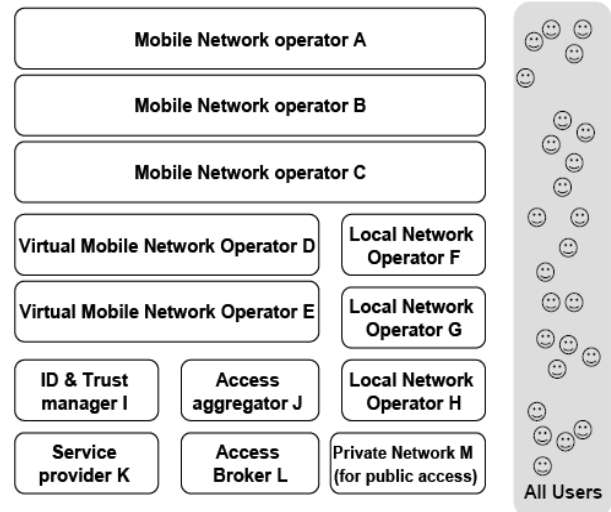


Figure 4: Market Actors in Ambient Networks

Figure 4[4] shows the key market actors which will play important role in Ambient networks, for the sake of simplicity some business model roles (Clearing House, Compensation service providers) are intentionally avoided. We will briefly look at all these potential “Market Movers”; which includes Local Network operators, Access Aggregator, Access Broker, service provider and ID & Trust Manager.

Local Network Operators- LNO provides local network access and services to local costumers. For example,

local network can be provided in chain stores which might also be used to provide services.

Access Aggregators will aggregate and bundle lots of local access providers that are LNOs. Access aggregator came into act due to presence of large number of Local Network Operators.

Access broker provides end to end connections between access providers and access aggregators. It could also have billing relationships with customers, where as its customer ranges from end user to Mobile Network operators.

Service provider works like access aggregator, it bundles services for customers. As ambient networks will deal with wide range of customers and access networks, it needs to have higher service availability for all the users.

ID & Trust Manager is used to provide common ground for all the parties who trust one existing body for secure activities that includes authentication, authorization, id management and payment issues.

4 BIG Picture

Through business model the realization of network composition and its market actors is done previously. Now it can be summed up through different approaches to make a BIG picture of Ambient Networks that is the concept of value network comes in integration of market actors and composition.

Value Network can be defined as *a web of relationships that generates economic value and other benefits through complex dynamic exchanges between two or more individuals, groups or organizations. Any organization or group of organizations engaged in both tangible and intangible exchanges can be viewed as a*

value network, whether private industry, government or public sector.

Market actors as discussed earlier are involved in making complex value network, aiming to benefit each other through cooperation and competitiveness following rules and regulations imposed by regulatory authorities. In such a 'value network' each player has different capabilities and resources.

Figure 5[7] illustrates market actors' interaction in one of the most simplified forms. The presence of thousands of actors around the world makes it **complex** and challenging. As the business model is fragmented into different market actors, it creates new aspects of making relationships among these actors.

Governance is an important aspect of organizational arrangements in value network. Value network governance must be distributed in three strong bodies [2]. First the basic rules for participating in the value network have to be set. Secondly, it is necessary to audit performance and check compliance with the set rules. Thirdly, value network participants may be supported in meeting the rules. The question that raises eye brows for small players is who is the '**governor**'? The business models for ambient networks keeps Mobile Network Operators (MNO) as heart throbs of network, which creates **insecurity of small players**, as they can be easily swept according to organizational goals of MNOs. Many of these actors can be combined to reduce the complexity but increasing burden on each. As far as user is concerned, all these complexities must be hidden from him as he gets only one monthly bill. Actual purpose was to provide lower **transaction cost** among these market actors in value network in order to make it a realizable business model.

The cooperation between small business operators (new entrants and local operators) and big players is a must in

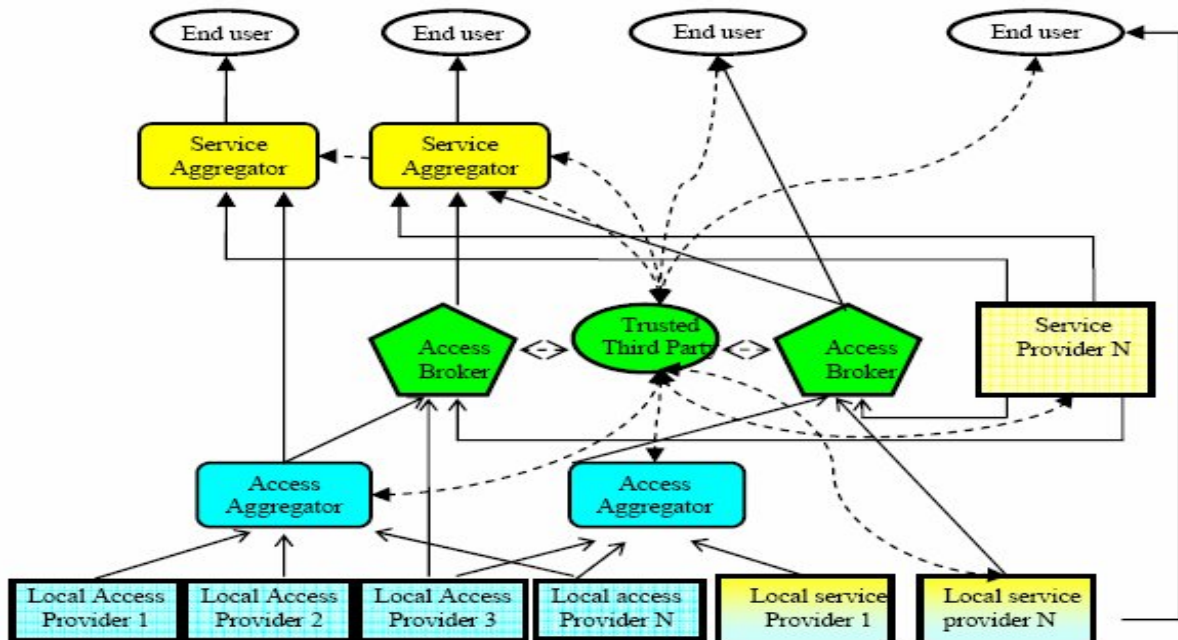


Figure 5: Market Actors in Value Networks [6]

order to provide a cost-effective solution. The **real trade** between big and small players is that big players can benefit as they do not need to deploy their own infrastructure. On the other hand the small players can take advantage of the larger customer market of the big players. **Market readiness** is one of the most crucial and difficult factors when starting a new service based on technology [2]. A technology like VoIP for example already existed for years, but was only recently adopted in the marketplace. One of the hurdles for new entrants in value networks could be high **technical sophistication**.

Small players are also affected by **rate of technological growth**. As the investment on small players' part increases, on the other hand they can also take advantage of saving the **marketing cost** as the big players will market their network and services anyways. Moreover, providing a new service via local operators involves lesser **investment risks** as risk cost will be distributed among different market players.

5 Regulatory Aspects

Regulation in telecommunications has proven to result in greater competition in market, economic growth, increased investment, lower prices, higher penetration, and more rapid technological innovation in the sector. The exponential growth in both the telecommunications customers and devices brought changes in traditional regulatory theories, which are often successful in other sectors rather than telecommunications. Regulations will remain important to take care of new market entrants from havoc of giants with monopoly. Ambient Network brought new regulatory changes as well [3], including

New Market Entrants are awarded with licenses according to demand and supply of particular area. It provides new opportunities for local wireless hotspot operators with local licenses or short term licenses.

Dynamic Roaming must be implemented with ambient networks as it is the aim of ambient networks to provide interconnection in heterogeneous networks. Here regulation can play part as directive on agreement format and procedures [3].

Authentication is also important aspects of ambient regulation. Authentication must be insured by regulation to be non-discriminating but considering the service package and age factor of consumers.

International presence must also be regulated. Just as the presence of Ambient network at city level, there must be international presence of ambient network with the same flexibility as for the local presence of operators.

6 Conclusions

The paper briefly discussed **Conceptual Frameworks for Interconnection of Heterogeneous Networks**, with the focus on technical architecture, business model and regulatory aspects. Composition of network, Mobility and Heterogeneity are defined in technical perspective. The paper further explains the complexity of business model, where Technical, financial, organizational, and professional user or consumer's needs and requirements need to be balanced. The big picture discusses some of the important aspects for consideration for making an ambient value network. Regulatory aspects were finally discussed to point out changes required in standardization and government policies for realization of the AN.

It can be concluded that AN is a new, exciting and upcoming business opportunity which promises a large number of customer services at low cost. However its realization requires removal of insecurities of small players or new entrants, as ambient value network gives high priority to big players (MNOs) to govern. Also business complexities, such as, transaction cost, risk minimization, marketing cost and investment risks, should be taken into account.

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