WIRELESS WORLD

RESEARCH FORUM

Recommended Template for Abstracts for Contributions to the WWRF17 Meeting

Using this template will provide the reviewers with uniform information, which will simplify their work. Please delete the guidance given between < > when typing.

1 WG or SIG to which this Contribution is submitted[1]:

WG2 Service Architecture

2 State which of the categories

a)

3 Title of research item

MULTINET: Enabler for Next Generation Services

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5 Subject area (WG/SIG and subtopic (as of CfC) where appropriate)

WG2 Service Architecture – Enabling Technologies & Standards

6 Relevance of the topic to the above subject area

MULTINET Technology (www.ist-multinet.org) is focused on new concepts for network, control and protocols, inter-domain routing and traffic engineering for delivery of new added-value services, with Quality of Service, security and end-to-end network connectivity, including IPv6.

MULTINET activities focus on providing the following results:

- Architecture supporting User-Initiated Network-Supported Multimedia Services for Nested Multihomed Mobile Networks.

- Tools and protocol for seamless broadband multimedia session delivery across heterogeneous networks.

[1] If you are submitting this contribution to several WGs/SIGs, please state to which and stress to which you would prefer have it presented.

- Middleware techniques for application layer service to adapt to underlying bearer characteristics.
- Mechanism for bearer services to adapt to the changing nature of multimedia applications.

7 Preferred presentation form: < speech or poster >

Speech

8 Abstract

Current broadband applications provided to the enterprise require from increased speed, performance, degree of personalization, ubiquitous access and reliability. 4G broadband wireless systems and multihoming technologies provide a working framework where such challenges could be met. In the context of a user driven broadband multimedia service and heterogeneous multiple-flow communication network supported system, this paper presents the MULTINET architecture as an enabler for next generation service delivery. The paper will discuss the main entities involved in the system and the main functionality supported. The paper will also highlight initial architecture set-ups and evaluate benefits and drawbacks of the proposed configurations to meet the identified QoS requirements

MULTINET: Enabler for Next Generation Services

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Abstract— Current broadband applications provided to the enterprise require from increased speed, performance, degree of personalization, ubiquitous access and reliability. 4G broadband wireless systems and multihoming technologies provide a working framework where such challenges could be met. In the context of a user driven broadband multimedia service and heterogeneous multiple-flow communication network supported system, this paper presents the MULTINET architecture as an enabler for next generation service delivery. The paper will discuss the main entities involved in the system and the main functionality supported. The paper will also highlight initial architecture set-ups and evaluate benefits and drawbacks of the proposed configurations to meet the identified QoS requirements.

***Index Terms*—Broadband Wireless, Services, Multihoming, NGN, MCoA**

I. Introduction

With the advent of 4G systems the use of heterogeneous communication systems in a transparent manner will effectively facilitate the deployment of ubiquitous services. The availability of multiple communication networks allow data communications and services, providing mobility to users with improved performance connectivity technology, facilitating seamless and intelligent mobile broadband communications at a lower cost, either in terms of battery power consumption or price. This strategic objective is developed by providing European large enterprises and SMEs with the necessary mobile broadband technology to support the Always Best Connected (ABC) paradigm communications. The heterogeneity and multiplicity of networks, available at various locations will enhance the user experience in terms of improved service performance, perceived Quality of Service (QoS) and reduced costs.

This is achievable by means of the MULTINET communication system which will be capable of providing the network and application functionalities so that multiple simultaneous networks can be seamlessly handled to optimize communications in multiple dimensions; while sustaining the existing mobile industry and attracting new business revenue.

The capabilities provided by MULTINET will facilitate high quality mobile broadband multimedia communication services at optimum cost, tailored to the communication requirements. The MULTINET technology provides the necessary networks and application functionality enhancements for seamless

data communication mobility in a scenario where the user can benefit without intervention from simultaneous transparent network connectivity among the available access networks to benefit from ubiquitous access to broadband applications.

Current broadband applications provided to the enterprise account for Mobile Office applications (PIM, email, messaging…), which will evolve in the near future into a Mobile Workforce (Sales Force, Field Engineers, Logistics…). However, to unveil the full potential benefits of broadband communications to the enterprise it is necessary to develop the IP and network connectivity management functionality which grant access to strategic information assets, i.e. realizing the Mobile Enterprise Applications - ERP, CRM, SCM, PLM. This demands that a more intelligent and flexible use of the available wireless infrastructure is achieved meeting these requirements.

Base on the scenarios described in [2] a number of common needs have been identified as drivers for next generation service enablers. The common needs include:

- Need to Accelerate Transmission at users indication.
- Need to Autonomously Redirect Established Sessions
- Need to Set Up Preferences
- Need for Ubiquitous Access
- Need for Reliability

Current IP-based wireless broadband communication systems suffer from limitations in the aforementioned aspects. It has been only recently that new mechanism to handle multiple IP addresses and managing mobile nested networks were proposed [3]-[8]. Bearing all these requirements in mind and the new emerging multihoming technology, the following paper presents a MULTINET architecture and some initial conclusions on most suitable IP and flow management configurations analyzed.

The paper is organized as follows. Next Section will present the MULTINET reference architecture. Afterwards, some working assumptions will be presented and the main issues regarding IP configurations in a multi-homed environment will be discussed within the scope of the proposed architecture. Finally, the main conclusions will be drawn and future lines of research detailed.

II. MULTINET REFERENCE ARCHITETURE

The previous Section has presented the main issues and scenarios addressed by the MULTINET system. The MULTINET reference model is intended for user-driven network-supported approaches to next generation services.

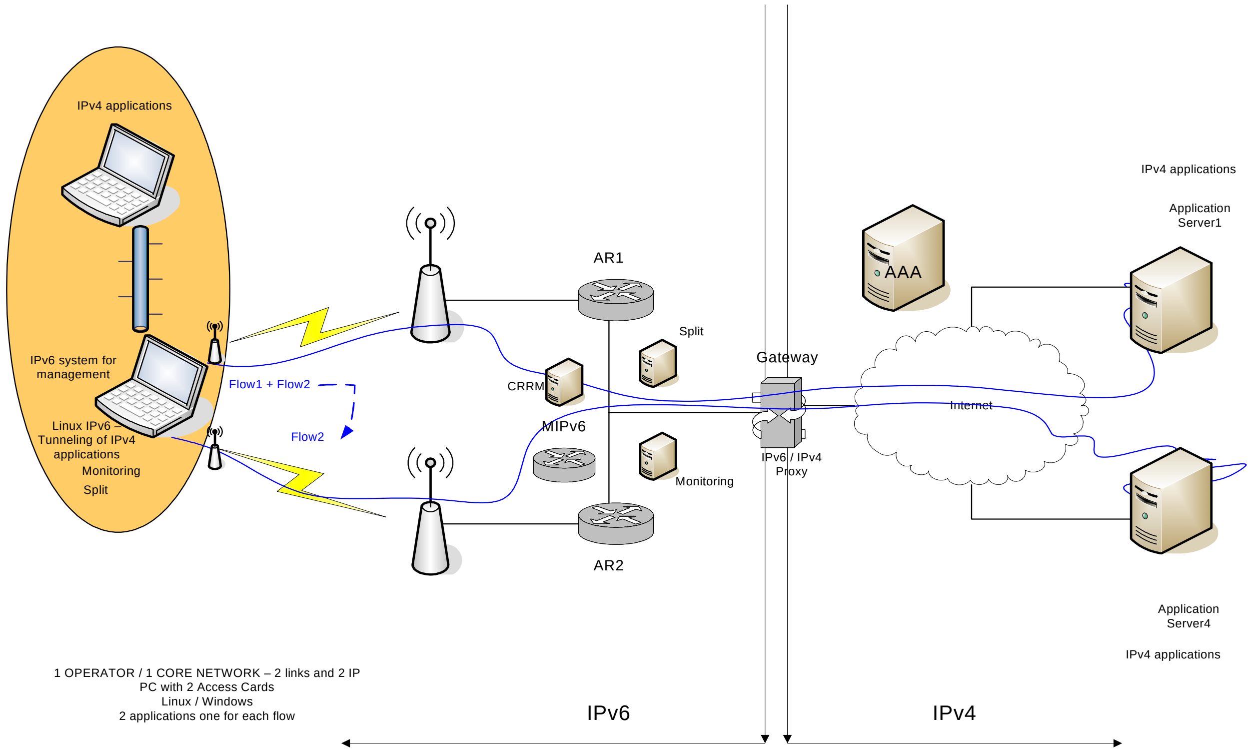

Figure 1 – Multinet Reference Model

Next generation communication systems will be characterized by a number of wireless communication systems that will cooperate in a seamless manner. Thus, the number of possible network parameter configurations and ultimately the number of options presented to the user will increase significantly.

It is generally acknowledged that early identification, adoption and continuous evaluation of user-requirements in technology development processes is advantageous in terms of succeeding in developing sustainable advanced communication services and applications from a business perspective. Thereby, user is put in control of the communication experience. However, this paradigm shift implies in many cases that complex decisions are left to the end user. Hence, it is necessary that mechanisms are in place to ease the decision making process for technology illiterate end-users.

MULTINET advocates an approach where the user is in control of the communication process and expresses their communication needs through simple commands, e.g. increased speed, increased reliability, increased QoS. These dynamic needs are translated into network level commands through appropriate middleware functions and decisions are supported through advanced network algorithms. The development of such middleware allows that the user is leveraged from complex network configurations through interaction with simpler interfaces. This approach supports wider adoption of next generation services.

This approach follows the experience gained through complex mobile communication systems such as UMTS, where the set of most common configuration parameters supported by the Network Operators are defined and agreed in advance in order to optimize network performance and QoS provision. In this way, it is possible to reduce uncertainty and work with a manageable degree of complexity.

The reference model adopted by the MULTINET project is depicted in Figure 1 The proposed reference model is addressed mainly for **nomadic users** with restricted user mobility. This is particularly intended for the scenarios addressed by the MULTINET project, mainly mobile working forces. MULTINET reference model aims at supporting with advanced features of next generation services.

MULTINET targets following key features:

- **Use of wireless access networks.**
- **Seamless perception of the user to network connection**. The ABC (Always Best Connected) paradigm targeted by Multinet frees the user from selecting a particular network, as it is the system's intelligence decides the most suitable access network. Nevertheless, the user can have access to a configuration facility which represents an input for the corresponding decision algorithm.
- **Flow management support.** Traditional services such as Internet browsing, multimedia services and file downloads are already supported by wireless networks (GSM, GPRS, WLAN), MULTINET targets broadband multimedia service delivery supported on flow management basis (flow split and handover) taking advantage of the various networks interfaces available to the nomadic user in their network.

The MULTINET reference model defines an open access platform supporting IP-based multi-media services, endowed with the desired functionality in terms of:

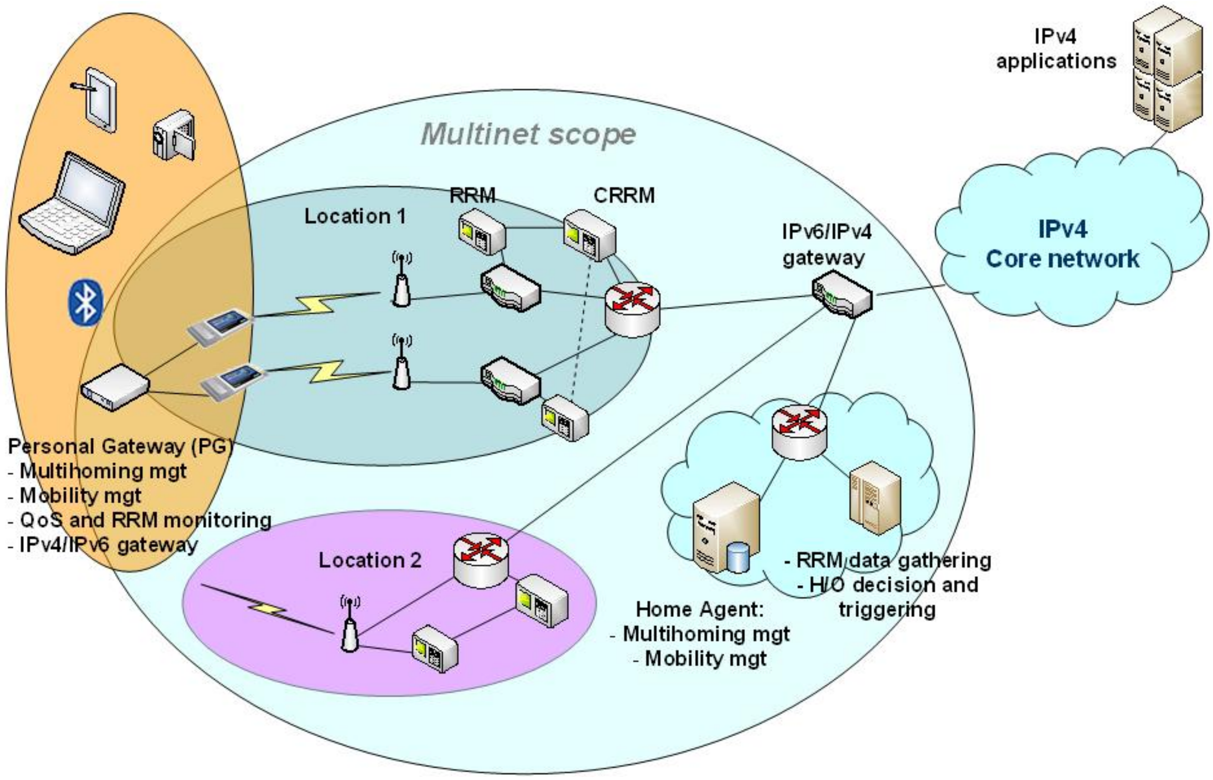

Figure 2 – MULTINET Architecture

- Multihoming
- Load balancing
- Dynamic bearer selection
- Service-aware best-connection and QoS intelligence

It is worth noting that the MULTINET approach does not put additional requirements on the application side. With this respect the proposed reference model decouples "standard" windows-based applications from the advanced MULTINET functionality. This reflects on the development of a Personal Gateway as will become apparent in the following Sections.

The heterogeneous broadband wireless scenario is considered in terms of multiple radio access availability. Initial reference model targeted should consider WLAN-WLAN scenarios while more advanced reference scenarios will meet the needs of WLAN-Wi-MAX and even UMTS operation. From such approach, it becomes apparent that multi-operator operation could be introduced into the MULTINET reference model as the complexity of the solution evolves.

MULTINET is fully supports IPv6 protocols. However, legacy support is also addressed by means of suitable IPV4-IPv6 gateway implementation. As depicted in the reference model various gateways both network and personal are considered at suitable locations, where traffic from/to the Internet can be seamlessly handled in parallel flows and supporting multiple IP addresses for the user network.

One important feature in the reference model above is the fact that a Common Radio Resource Manager is capable of optimizing load balancing and dynamic bearer decisions for each flow. Furthermore, these decisions are based on user initiated service-aware QoS requirements.

The user environment is split into two domains:

- **User devices.** The user device tends to be a simple device, a common laptop, PDA where changes in the applications are avoided or minimized. This allows the use of a Windows platform and common applications. The network driver also runs a common IPv4 stack if required, so less demanding requirements are put on the terminals. This separation is particularly relevant when we consider mobile workforces that normally cooperate in the field and where it is advantageous also to coordinate the communications of the various devices involved in a particular task transparently to the working team.
- **The personal gateway (PG).** The PG allocates part of the workforce team communication environment intelligence. The PG represents a multimode device that permits the use of both many access networks simultaneously or switch from network to network. It provides at least functionalities for mobility, multihoming and IPv4/IPv6 translation support.

The **Access Router (AR)** represents the external router of each access network; this means that any packets arriving from a different network must traverse this AR for establishing contact with any of the nodes located in this access network. This is typically the case of a Corresponding Host (CH) contacting the Mobile Host (MH) through the interface of the PG connected to the AR. As the Multinet platform comprises several wireless access network, each of them will have an access router. It is assumed that all ARs are communicated where other entities – Common Radio Resource Management, Monitoring Manager, Split Manager - are also attached.

The **Common Radio Resource Management (CRRM)** provides supports to the PG in order to determine the best access network (AN) for a given application and in the handover process, since the PG cannot optimally fulfill this process autonomously due to lack of overall knowledge of network conditions.

The **Monitoring Manager** is responsible for collecting information about how the radio resources are being used. It implies inspecting at a flow-level QoS performance. This entity is also responsible for security mechanisms

The Multinet platform handles the split of a flow for service delivery to various IPs related to a single user device. Thus, fractional network bandwidth could be exploited. Without flow splitting individual service performance suffers in terms of both delay and throughput, since there may be insufficient resources to satisfy all service flow QoS requirements. Furthermore, within broadband wireless networks lack of flow-splitting functionality also translates into overall system performance degradation, since each services contends for the resources available and this impacts negatively on already established network connections. The **Split Manager** is responsible for managing multiple flows belonging to the same session. Thus, the corresponding host only perceives a single, high bandwidth flow.

III. MULTINET FUNCTIONAL ARCHITECTURE

The previous Section has presented the main components of a reference MULTINET architecture and the main entities.

One of the most relevant features of the MULTINET architecture is the capability of the PG, as an extension of the devices and applications attached to it, to benefit from simultaneous connections to various communication networks. This situation demands that the means to identifying the user devices, sessions and flows operating over the PG are identified univocally. To satisfy this requirement various options exist based on the entity which is in control of the configuration process. The aim of this Section is to present the functional aspects related the MULTINET approach in this context and discuss some associated implications. Current research work focus on Multiple Care of Address and flow distribution aspects. However, discussion in this Section mainly focuses on implications from IP address configuration perspective for user and application identification.

A. *Working Assumptions*

The MULTINET functional architecture is based on the outputs of analysis of three different potential solutions to IP address management supporting Mobile IPv6, namely:

- Single IP address based solution that is network-centric;
- Multiple IP address based solution that is user-centric;
- Multiple IP address based solution that is network-centric

These approaches each present their own particular motivations and challenges. To facilitate discussion we will consider two access networks, ANA & ANB with associated IP address blocks [a1 … an] and [b1 … bn] respectively. The presence of an intelligent server is also assumed, which is in charge of controlling and diverting data flows accordingly. Its location in the architecture diagram below suggests that it executes access network selection in conjunction with the Network Intelligence Server, based on port addresses. Due to its location in the network it is referred to as the pivot router. As we will discuss later in the paper, for a multiple IP address solution,

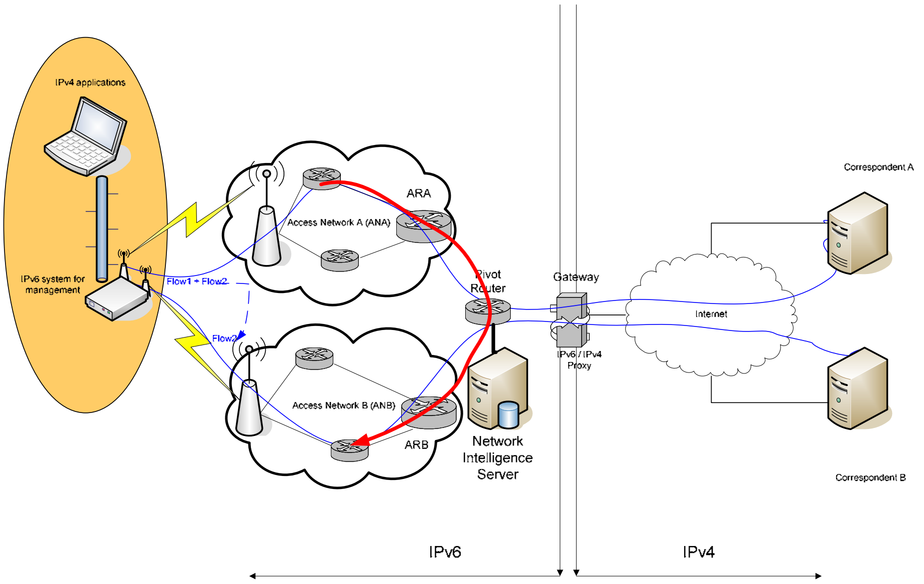

Figure 3 – Routing Between ANs

this component operates as a traditional router, forwarding packets based on destination IP address.

The network operator provides standard telecoms and Internet services in addition to the Multinet solution. The Multinet solution must not interfere with pre-existing IP solutions for non-Multinet users either in the core or access network. Non-Multinet users attached to access network ANA, for example, must be able to communicate with, and hence route to, other users in the Internet and also access network ANB. Thus, any packet within ANA with a destination address associated with ANB will be forwarded to ANB via the pivot router. This requirement has implications for the single IP address solution, as will be explained in the next section.

B. *Single IP Address Approach*

In the case where a wireless node has a single IP address, the address can be obtained from the IP block associated with either ANA or ANB. The user's MIPv6 Home Agent must be notified of this address using a standard Binding Update (BU). One potential problem in the MULTINET scenario is that the *single IP address approach may lead to a forwarding loop*.

The forwarding loop problem can be explained as follows. The MN is configured with an IP address from ANB, b1, and wishes to receive flow fa (at port pa) through ANA and flow fb (at port pb) through ANB. On receipt of a packet, in the downstream direction, addressed to b1 on port pb, the packet is forward to ANB and on to the MN. However, on receipt of a packet addressed to b1 on port pa, the router will attempt to forward the packet to the access router of ANA. Since the routing tables within ANA indicate that the route to b1 is via the pivot router, the packet will be returned giving rise to a forwarding loop. Clearly the loop prevents the packet being forwarded downstream to the MN attached to ANA.

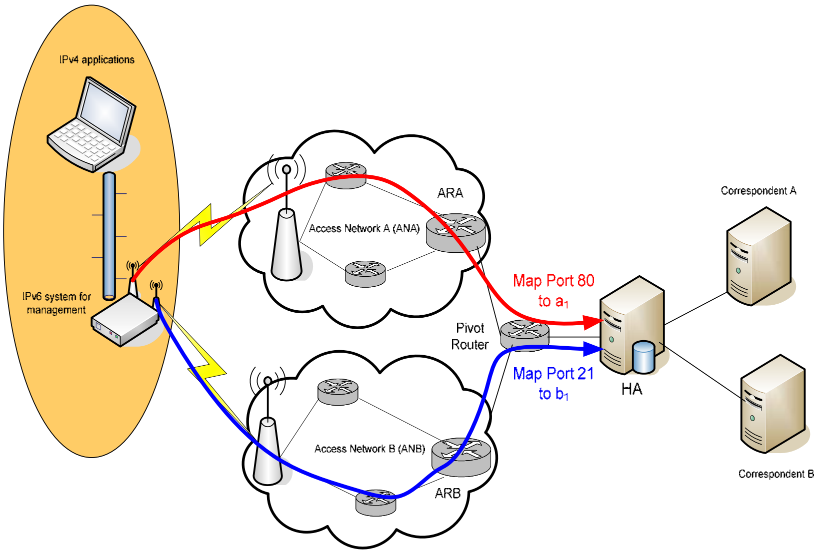

Figure 4 – Modified Binding Update

The forwarding loop would likely occur during flow handover process. In order to prevent such a loop, the routing tables of the routers within ANA must be updated in order to forward packets towards the wireless access point and hence on to the MN. The problem associated with this approach is that packet loss may occur during the period before routing updates are propagated to the routers.

There is also the issue of egress filtering. Egress filtering is the process by which networks block outbound packets from addresses that are not topologically correct. In the example highlighted ANA would filter out any upstream packets originating at the MN because its address (b1) is not associated with ANA, i.e. is not in the range [a1 … an].

Scalability issues may arise: whenever a mobile node attaches to an access network, the routing tables of all the other access networks must be updated; it should be noted that there may be several access networks. For example, when the MN configures itself with address b1, every other AN to which the MN is also attached must have its routing tables update to identify the shortest path to the MN. It should be noted that there may be more than the 2 ANs considered in this example.

C. Multiple IP Address Approach. User-Centric

In this potential solution a mobile node obtains an IP address from each access network to which it becomes attached. This approach permits simple flow management since the terminal can unilaterally map specific flows (via port numbers) to specific addresses. For example, the terminal could utilize address a1 for port 80 (web traffic) and address b1 for ports 20 & 21 (FTP traffic), as shown in Figure 4. Under this circumstance the pivot router simply routes traffic based on the destination IP address, i.e. there is no requirement to inspect port numbers at the pivot router.
The Multinet solution should not be dependent on correspondent nodes also being Multinet-enabled. Therefore, it must be assumed that the correspondent node is unaware that the mobile node has multiple IP addresses and that flows are being partitioned across those addresses. Consequently, an intermediate node in the network is required to forward packets to the correct IP address. This translates into a requirement for the mobile node to send updates to an intermediary containing its flow-address mappings, and for the intermediary to tunnel those flows as appropriate. The most appropriate choice for such a network element would be MIPv6 Home Agent-based approaches. Thus the home agent would inspect all incoming packets and tunnel them to the most appropriate (out of many available) IP address towards the mobile node. This procedure is depicted in Figure 5.
The problem with this approach is that the HA would be required to manage a range of CoAs. The mobile node would also be required to send modified binding updates to the home agent that include the port addresses to be associated with a specific CoA; therefore MIP may have to be modified to permit registration of multiple CoAs. A need for the HA to have multiple CoAs has already been

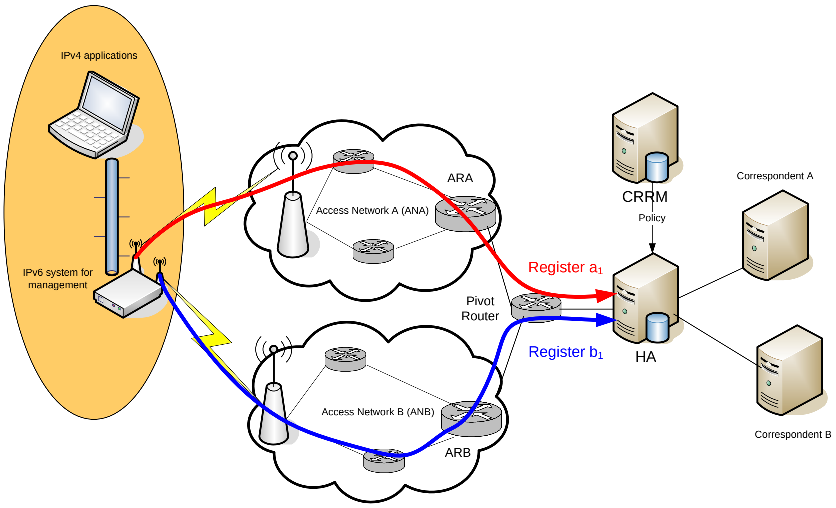

Figure 5 – Multiple Care of Address

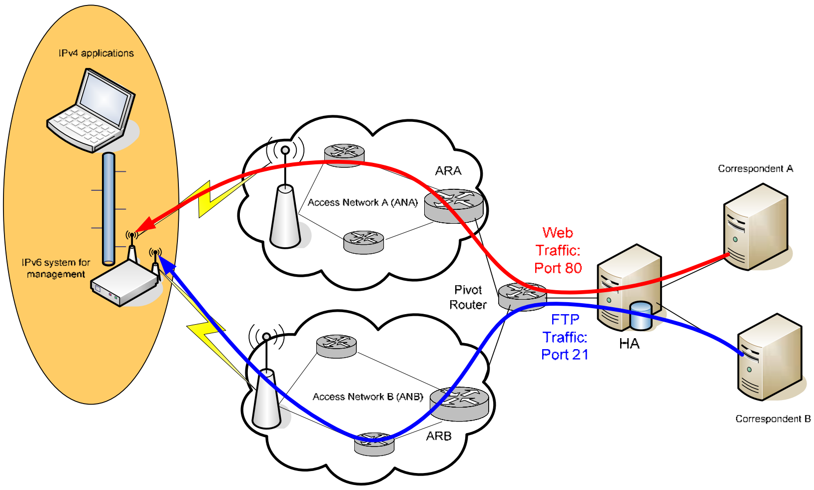

Figure 6 – Multiple IP

recognized and means of signaling this information is proposed in [1].

A further disadvantage of this approach is that the HA must remain as an intermediate node between the mobile node and correspondent node for the duration of each session so that it can handover flows as directed by the mobile. Thus, route optimization is not possible. Since the HA must always remain as an intermediate node this could lead to localized congestion.

It should be noted that this approach is a user-centric approach to handover decision and execution since it is the terminal that is selecting the most appropriate network by virtue of sending binding updates to the HA.

D. Multiple IP Address Approach. Network-Centric

This approach is a variant of the second case whereby the MN sends binding updates to the MIPv6-based HA. The idea is that the BUs register multiple CoAs with the home agent: one per interface. Unlike the second case, no port information is associated with each CoA registration; therefore, the HA will have total discretion in mapping flows (via port addresses) to CoA and hence ANs. An intelligent network element, e.g. the CRRM, could generate a mapping policy on a node per node basis and send the policy to the HA, as shown in Figure 6.

This approach enables the network to retain control of the direction of flows in the flowing manner. The CRRM could operate intelligent network selection algorithms that generate a policy which informs the HA to forward all web traffic (port 80) over ANA and all FTP traffic (port 21) over ANB, for example. The HA would then implement the policy by mapping all port 80 traffic to CoA a1 and port 21 traffic to COA b1.

E. Summary

This Section has presented the functional aspects of various IP configuration schemes. Based on the conditions imposed on the network elements, the necessity to leave applications unmodified on the user terminal and the potential for future developments, the MULTINET approach is supporting a network-centric multiple IP address configuration approach. The MCoA approach permits further flexibility and is a suitable compromise in terms of system performance, scalability and the network capacity to support optimal resource and flow management based on QoS requirements and support to dynamic user-initiated Service Level Agreement reconfiguration.

IV. Conclusions

This paper has presented the MULTINET approach to enable next generation services. MULTINET reference architecture facilitates a user initiated network supported approach, which relies on the availability of a Personal Gateway with support capabilities for mobility management of nested networks, multihoming and IPv4/IPv6 translation for mobile working force applications.

The advantages and drawbacks of three different IP configurations on the MULTINET scenarios have been presented and a preliminary solution based on a Common Radio Resource Management scheme and Multiple Care of Address capabilities discussed. Current work is focusing on flow distribution management and CRRM algorithm definition.

Acknowledgment

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