TSG-RAN Meeting #12 **RP-010416**
Stockholm, Sweden, 12 - 15 June 2001

Agenda Item: 8.3.2
Source: **Motorola**
Title: IPv4 Transition to IPv6 in IP UTRAN – The dual stack approach
Document for: Decision

1 Introduction

Motorola do not agree with the stated agreement currently in section 7.15 "IP version issues" of the IP Transport in UTRAN TR 25.933. There have been long discussions at the previous RAN 3 meetings on this issue, but the subject has not been concluded. Motorola request that RAN ask RAN 3 to keep this area open for further discussion until the next RAN plenary.

The current text is not in line with the architecture that has been studied and approved within S2 - TS 23.221. A LS has been sent to RAN 3 informing them of this in document Tdoc S2-011572, S2 have not met since the reply (TSGR3#21 (01)1868) was sent.

Motorola believe that, with sufficient allocated meeting time, RAN 3 should be able to resolve this issue before the next RAN plenary meeting. The remainder of this document is supplied for information to RAN just in case RAN decides to have a technical discussion in this area.

2 Terminology

The following definitions apply as defined in [1]:

Type of nodes:

IPv4-only node**:** A UTRAN node or router that only implements IPv4 and does not understand IPv6. (The entire installed base of routers existing before the transition (today) are IPv4-only nodes.)

IPv6/IPv4 node**:** A UTRAN node or router that implements both IPv4 and IPv6.

IPv6-only node**:** A UTRAN node or router that only implements IPv6 and does not understand IPv4.

IPv6 node**:** Any UTRAN node or router that implements IPv6. IPv6/IPv4 and IPv6-only nodes are both considered IPv6 nodes.

IPv4 node**:** Any UTRAN node or router that implements IPv4. IPv6/IPv4 and IPv4-only nodes are both considered IPv4 nodes.

Modes of operation of IPv6/IPv4 nodes:

IPv6-only operation**:** An IPv6/IPv4 node with its IPv6 stack enabled and its IPv4 stack disabled.

IPv4-only operation**:** An IPv6/Ipv4 node with its IPv4 stack enabled and its IPv6 stack disabled.

IPv6/IPv4 operation: An IPv6/IPv4 node with both stacks enabled.

3 Description "Aspects of IPv6 transition"

The purpose of this contribution is to propose the use of the Dual Stack approach in the UTRAN nodes, as defined by the IETF in [1] as the most straightforward transition mechanism from IPv4 to IPv6. References [1] and [2] describe the dual stack mechanism.

3.1 The transition from Ipv4 to Ipv6 – Technical Issues

Currently, there are “only” IPv4 networks deployed around the world. IPv6 seems to be the protocol that will be implemented in the future since it provides several enhancements compared to IPv4 in terms of addressing, mobility and multicast support. However:

1) It is not clear when IPv6 will start to be widely deployed, and as of now there is only a test bed (6bone) that is testing IPv6 functionalities for internet support,
2) As stated in [1], section 1, it is expected that the IPv4 networks (nodes and routers) will be operating for a long time and perhaps even indefinitely. The interworking between IPv4/IPv6 is the main issue to address in the transition in order to provide a flexible evolution from IPv4 to IPv6 routers and nodes.
3) For the UTRAN purposes, IPv4 provides **“now”** all the functionalities required for the transport of the user and control data over Iub/Iur and Iu interfaces, since the new functionalities and enhancements of IPv6 (multicast, addressing and Mobile IP) are not used for the UTRAN interfaces, and
4) The interworking with the today IP UMTS nodes (i.e. R99/R4 Iur/Iu RNC IP transport and R99/R4 SGSN Iu transport that are specified with IPv4 as mandatory) shall be supported and performed with a solution that avoids complex techniques.

3.2 Network scenarios and transition mechanisms

Current scenario

In today’s Operator networks, only IPv4 is widely deployed, offering in many cases, the entire routing infrastructure needed to carry the UTRAN traffic.

In this case, the introduction of UTRAN IP nodes using the existing network depends on the UTRAN node IP version used:

a) UTRAN nodes are ***IPv4-only nodes***: This is the native version of the actual IP networks, so there are no interworking impacts with the introduction of the UTRAN nodes. All the data will be “routed” inside the IP network per the hop-by-hop approach of IP.

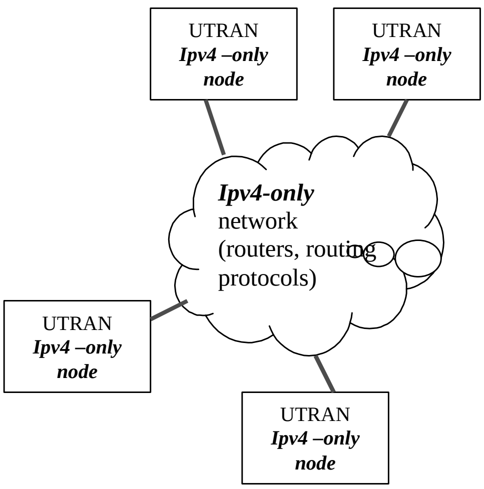

Figure 1. Introduction of UTRAN ***IPv4-only nodes*** in the current IPv4 networks.

b) UTRAN nodes are ***IPv6-only nodes***: In this case, in order to allow full connectivity between the UTRAN nodes (needed for e.g. the Iur interface), it is needed to apply some of the techniques explained in [1] and [2] based on the use of tunnels:

- ***Configured tunneling***: According to [2], this is the most common option to be used between IPv6 nodes in an IPv4 network where traffic will be exchanged regularly. The configured tunnel needs a dual stack "IPv6/IPv4" edge router; in charge of encapsulating the IPv6 packet in an IPv4 packet to travel across the IPv4 network. As a limitation, a) the tunnel will not work if it has to cross a NAT (Network Address Translation) box, b) one dual stack Edge router is needed per location/node, c) every edge router has to be manually reconfigured when a new UTRAN node is added in order to configure all the new tunnels needed for the communication and d) in this scenario, it is not possible to use/test the IPv6 capabilities regarding QoS, routing, etc. All the features will be based on IPv4 since all the IPv6 datagrams are transported over IPv4 tunnels.

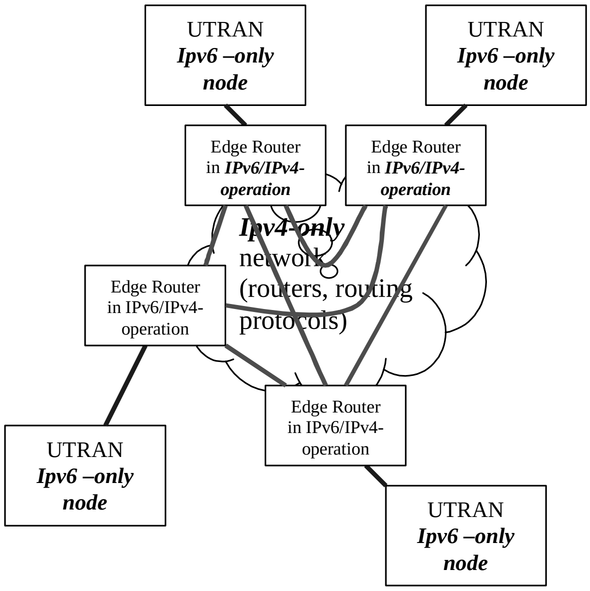

Figure 2. Introduction of UTRAN ***IPv6-only nodes*** in the current IPv4 networks.

- There are also other techniques used such as Automatic tunneling, Tunnel broker, 6to4 and 6over4, among others. All of these techniques impose similar requirements and limitations to the UTRAN IP nodes and IP network implementations. Refer to [1] and [2] for further details about these techniques.

c) UTRAN nodes are ***IPv6/IPv4 nodes***: In this case, the UTRAN nodes only need to use the IPv4 stack, whereby the UTRAN nodes can operate in ***IPv4-only operation*** (with IPv6 stack disabled) and acting as an ***IPv4 node***. In this case there is no need for interworking since all the nodes and network will be operating with IPv4.

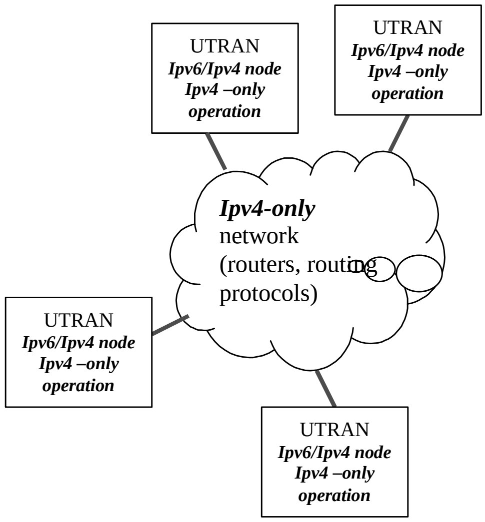

Figure 3. Introduction of UTRAN ***IPv6/Ipv4 nodes*** in the current IPv4 networks.

“Near” future scenario

In the “near” future, i.e. for the next few years, it is envisaged that IPv6 will start to be deployed. This deployment will be done in different phases. [2] shows possible steps to follow in order to migrate from Ipv4 to Ipv6 in the nodes and routers. The transition would start with island(s) of IPv6 routers in order to test its capabilities in a real environment. The firsts applications to use the test network will be the QoS tolerant applications (e.g. TCP/IP) in order to test it basic functionalities. However, it is possible for the operator to migrate (or place new) UTRAN nodes in order to test the performance of the UTRAN traffic over the IPv6 network.

With UTRAN ***IPv6-only nodes***, some UTRAN nodes will be connected to the Ipv6 network, and some would remain connected to the Ipv4 network, in this case there is still needed the use of tunnels between the Ipv6 edge routers, with the implications already mentioned.

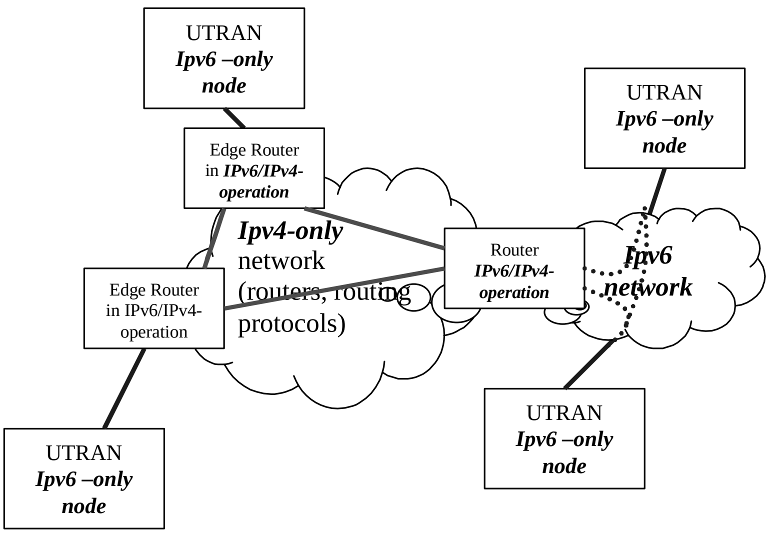

Figure 4. Near future scenario using UTRAN ***Ipv6-only nodes***.

With UTRAN ***Ipv6/Ipv4 nodes***, the UTRAN nodes can be connected to the Ipv4, Ipv6 or both Ipv6/Ipv4 network, depending on the operator network design. The UTRAN node intended to test the

Ipv6 network will have both stacks enabled, i.e. they will operate in **Ipv6/Ipv4 operation**, whilst the others will remain connected to the IPv4 network. This solution provides extra-flexibility to 1) test the IPv6 network without adding extra-complexity in the UTRAN Transport network, b) Avoid the use of tunnels and its implications and c) Migrate the nodes without disruption of the service, since it is only needed to “enable” the Ipv6 layer in the UTRAN nodes.

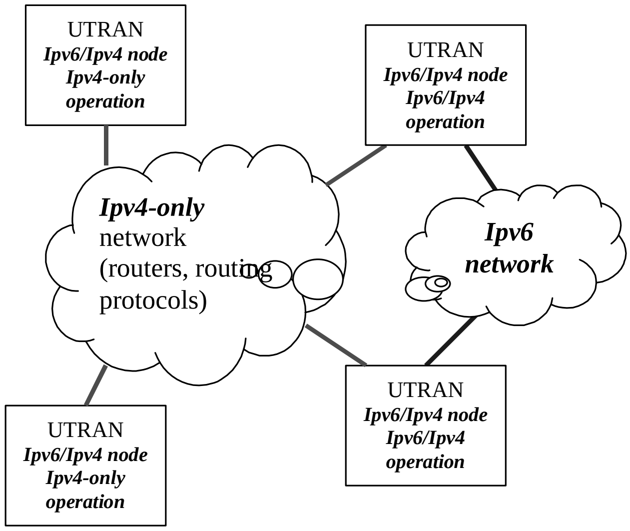

Figure 5. Near future scenario using UTRAN ***Ipv6/Ipv4 nodes***.

<u>Note:</u> It is not clear how fast the migration will take place, since there are several factors that can affect this migration: a) the availability of network equipment (routers) capable to handle Ipv6 and its associated features (QoS, IPSec, etc) in the same way as stability as Ipv4, b) The availability of Ipv6-aware applications, c) The performance of Ipv6 after testing in the real operator environment and d) other factors: economical decisions, etc. With this in mind, it is important to cover this scenario, since it could be in the same timeframe (or later on) as the UTRAN IP node deployment.

Long term scenario – Ipv6 in the business

Over the long-term, it is envisaged that IPv6 will be the protocol established in all the networks around the world. All routers and nodes have to be able to communicate across IPv6 networks, and the UTRAN nodes have to provide IPv6 on its interfaces. In this scenario, both UTRAN ***IPv6-only nodes*** and UTRAN ***IPv6/IPv4 nodes*** (in ***IPv6-only operation***) will operate in the native form, utilizing the full capabilities of IPv6.

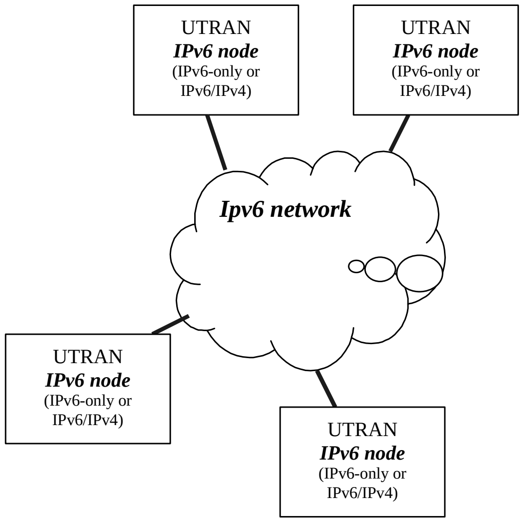

Figure 6. Long-term scenario using UTRAN ***Ipv6 nodes (IPv6-only*** or ***IPv6/IPv4 nodes)***.

However, as stated in [1], it is possible that IPv4 networks will remain in the market for an extended period of time or perhaps even indefinitely, depending upon the operator decision, i.e. the "near" future can replace the Long term scenario. In this case, the interworking between the IP versions would be needed. There are several possibilities depending on the use of UTRAN **IPv6-only nodes**, or **IPv6/IPv4 nodes**. For **IPv6/IPv4 nodes**, there is no need for interworking functions since the node itself provides the capabilities to handle both IPv4 and IPv6 network in the same way as in the "near" future scenario. For the IPv6-only nodes, the solution would be based on the tunnel mechanisms.

3.3 Backward compatibility and Interworking with R99/R4 Iur transport

The Iur IP transport in Release 99 and Release 4 are based on IPv4. So a R5 RNC should be able to communicate with a R99/R4 IP RNC in an efficient way, since the Iur interface will be deployed over all the RNS. With this in mind, the solution selected for the Iur interface shall allow the interworking without adding extra complexity to the implementation and the transport network and without imposing limitations to the IP capabilities.

- Selecting IPv6 as the mandated stack for the Iur interface, it means that in order to allow the Iur interface interworking with a R99/R4 RNC, the RNC or the transport network shall implement complex techniques like automatic tunneling, the use of IPv4/IPv6 compatible addresses, NAT-PT, SIIS, etc. These techniques introduce several limitations to the numbers of IP addresses that can be found in a node (e.g. only one IP address per node) and also impose a more complex interworking.
- Selecting dual stack as the mandated stack, the interworking with a R99/R4 (Iur) RNC is ensured and performed in the easiest and best efficient way, without the use of complex techniques like tunneling, etc. Also, this solution provides extra flexibility to the operator in order to allow them to upgrade the nodes in an independent way from the existing platform.

3.4 Backward compatibility and Interworking with R99/R4 IP transport in Iu interface

The Iu IP transport in Release 99 and Release 4 are based on IPv4. So, a R5 RNC should be able to communicate with a R99/R4 SGSN. With this in mind the selected solution for the Iu interface could impact the architecture of the UMTS depending on the IP version selected. The solution selected shall support the interworking with the R99/R4 PS domain in an efficient way, without imposing limitations to the IP capabilities.

- Selecting IPv6 as the mandated stack in the Iu interface, it means that in order to allow the interworking with R99/R4 SGSN, the RNC shall implement complex techniques like automatic tunneling, using IPv4/IPv6 compatible addresses, or the use of NAT-PT, or protocol translation etc. These techniques introduce several limitations to the numbers of IP addresses that can be used in a node (only one per node) and also impose more complexity interworking.
- Selecting dual stack as the mandated stack, the interworking with a R99/R4 SGSN is ensured and performed in the easiest and best efficient way, without the use of complex techniques like tunneling, etc. Also this solution provides flexibility to the operator in order to allow them to upgrade in an independent way the UTRAN from the CN.

3.5 The dual stack approach

General

The dual stack mechanism was designed as one part of a "transition toolbox" to support a gradual introduction of IPv6 into the existing IPv4 networks.

The dual stack mechanism is defined in [1] as "a technique for providing complete support for both Internet protocols – IPv4 and IPv6 – in hosts and routers". Also in [1] it is stated that the dual stack mechanism is "the most straightforward way for ***IPv6 nodes*** to remain compatible with ***IPv4-only nodes***".

A dual stack mechanism consists basically of the support for both IPv6 and IPv4 in the UTRAN IP nodes. However, as stated in [1], it is possible that a dual stack node (i.e. ***IPv6/IPv4 node***) may operate, in ***IPv6-only*** or ***IPv4-only*** mode; a configuration switch may implement the selection of protocol version. This is very useful in the case of introducing UTRAN ***IPv6/IPv4 nodes*** in ***IPv4-only*** networks (actual scenario), and in the long-term scenario, where it is expected to have ***IPv6-only*** networks. The ***IPv6/IPv4-operation*** will be used in the near future scenario and later on.

Although the Dual Stack technique, as described in [1], is enough to handle the migration from IPv4 to IPv6 networks, it is still possible to use the dual stack approach in conjunction with tunneling mechanisms, as an option. This provides extra-flexibility in the configuration of the networks by the operators.

Address configuration

Since the dual stack nodes support both protocols, IPv6/IPv4 nodes may be configured with both IPv4 and IPv6 addresses, depending on the operation mode, i.e. if the node is in IPv4-only operation (actual scenario), it requires only an IPv4 address, if the node is in IPv6-only operation (long-term scenario), it requires only an IPv6 address, and if the node is in IPv6/IPv4 operation, it requires both IPv4 and IPv6 addresses.

The IPv6/IPv4 nodes use IPv4 mechanisms (e.g. DHCP, manual configuration, etc) to acquire their IPv4 address and the IPv6 mechanisms (e.g. stateless address autoconfiguration, manual configuration, etc) to obtain their IPv6 address. There are other mechanisms described in [1] to acquire IPv4-compatible IPv6 addresses for the case where automatic tunneling is used by the IPv6/IPv4 nodes.

It is expected that all of the UTRAN node's IP addresses will be configured manually, for security and maintenance reasons (it is always easier to apply commands like ping, trace, telnet, etc. to specific boards or modules if the IP address is already known).

The only possible limitation that [1] envisages for the dual stack mechanism is that in the near future scenario all of the nodes connected to both IPv6/IPv4 network would require IPv4 addresses. However, for the UTRAN case it is not an issue, since a) the UTRAN networks are private networks, not accessible to the UEs, so there is no need to use public addresses, b) the number of UTRAN nodes in the same subnetwork is small, so CIDR techniques can provide enough granularity to address several UTRAN nodes with a class C group of addresses, and c) In case there is a need to access the UTRAN node from the internet, NAT mechanisms can be used to translate a public address to several private addresses.

DNS

In the Internet, the Domain Name Server (DNS) is used in both IPv4 and IPv6 to map between host-names and IP addresses. A new resource record type "A6" has been defined for IPv6 addresses in [4] with support for an earlier record named "AAA". Since **IPv6/IPv4 nodes** shall be able to interoperate directly with both **IPv4 nodes** and **IPv6 nodes**, they must provide resolver libraries capable of dealing with IPv4 "A" records as well as IPv6 "A6" and "AAAA" records. However, when a query locates an "A6/AAAA" record holding an IPv6 address, and an "A" record holding an IPv4 address, the resolver library may filter or order the results returned to the application in order to influence the version of IP packets used to communicate with that node, i.e. return only the IPv6 address to the application, return only the IPv4 address or return both addresses. This decision is implementation dependant, however, the implementation shall allow the application to control whether or not the filtering takes place.

The DNS capability in the UTRAN transport is not needed, and it is not envisaged to be used, since all the nodes and functionalities are static (i.e. it does not follow the same model as the Internet, where the content of the application can be located in several places). However, as implementation dependent, it can be used for both dual stack or IPv6 only nodes.

Complexity of dual stack implementation in comparison with IPv6-only

The term "dual stack" is somehow misleading because it is possible to misunderstand that this implies two separate HW and SW implementations in the node, one for IPv4 and one for IPv6, but as [2] states, "most implementations of IPv6 does not offer two completely distinct TCP/IP stacks, one for IPv4 and one for IPv6, but a hybrid stack in which most of the code is shared between the two protocol suites".

Most of the complexity when implementing dual stack comes from the complexity of IPv6, i.e. IPv4 is an already known and a widely implemented protocol suite, whereas IPv6 is a new protocol with some different requirements. It can be concluded that "if it is possible to implement IPv6, then it is possible to implement a dual stack, since, once IPv6 is implemented, there is little additional complexity for also implementing IPv4".

In fact, from an operator point of view, it is more complicated to connect ***IPv6-only*** nodes in the transition scenarios, since it would require the configuration and use of tunnels and dual stack routers from the beginning, making the planning quite complex in comparison with the dual stack approach in the UTRAN nodes.

3.6 Architectural Issues

In [6], section 5.1 "IP version issues" it is stated that (non relevant text is omitted):

"The UMTS/GSM architecture shall support IPv4 / IPv6 based on the statements below.

- *IP transport between network elements of the IP Connectivity services (between RNC, SGSN and GGSN) and IP transport for the CS Domain: both IPv4 / IPv6 are options for IP Connectivity*

- *The architecture shall make optimum use of IPv6."*

It is clear that [6] mandates the support of IPv4/IPv6 connectivity, so in order to meet this architectural requirement, some mechanism of IPv4/IPv6 interworking shall be taken. [1] Describes the dual stack approach as "the most straightforward way for ***IPv6 nodes*** to remain compatible with ***IPv4-only nodes***". Then, the dual stack approach seems to be the most adequate technical solution that complies with the architectural requirements in [6].

As explained in 3.4, the dual stack is the best way to comply with this requirement for the interworking of release 99, release 4 and Release 5.

3.7 Advantages of using the dual stack mechanisms for the UTRAN nodes

The Dual Stack mechanism, as defined in [1] provides several advantages over the ***IPv6-only*** implementation:

1. It allows a faster implementation of ***IPv4-only operation*** dual stack UTRAN nodes if the operator decides to install IP nodes in a short time.
2. It avoids the delays on IP UTRAN nodes deployment. It is well known that there are some open issues in the IPv6 protocol suite (use of flow label, QoS, sec, etc), required e.g. for the conversational traffic.
3. It allows the implementation of IP UTRAN nodes using the actual IPv4 infrastructure in a native way. If IPv6-only nodes are deployed, then the operator network (re) design shall include the use of tunnels, dual stack routers, etc adding extra-complexity and some limitations (use of NAT, etc)
4. It allows IPv6/IPv4 operation in the case of IPv6 networks that need to be tested or starting to be deployed in the field while remaining connected to the IPv4 network.
5. It allows the complete migration to IPv6 without disrupting the service.
6. It allows operators to migrate to IPv6 networks gradually without affecting the UTRAN performance.
7. It allows the gradual migration of the UTRAN in an independent way from the CN upgrading (removing the UTRAN dependency from CN IP version selected).
8. It is the best way to comply with the architectural requirements stated in TS 23.221 for all the actual releases (R99, R4 and R5)
9. After the complete migration to IPv6 networks (year 20XX), the IPv4-operation can be disabled, and the node will operate in ***IPv6-only operation***. At that time (release n), it would be possible to impose the requirement to use only IPv6 in the UTRAN nodes.

3.8 Conclusions

1. Dual stack operation provides several important advantages for the deployment of the IP UTRAN nodes, since it takes into account the migration scenario in terms of connectivity, performance and network deployment.
2. Dual stack implementation has almost the same level of effort as IPv6 only implementation
3. Dual stack operation provides flexibility to the operators in order to buy, test, configure, deploy and migrate in a gradual way from the IPv4 networks to IPv6 network without disrupting/affecting the existing UTRAN traffic.
4. Dual stack operation is compliant with the architectural requirements imposed in [6].

4 Proposals

1. Remove the current agreement from [5] section 7.15 “IP version issues”
2. Add the following text in [5] section 7.15, ”IP Version issues”.

“The UTRAN nodes terminating IP UTRAN interfaces shall support the IPv4/IPv6 dual stack mechanism as defined in IETF RFC 2893 [x]”.

3. Add section 2 to [5] section 3.1 “definitions”
4. Add section 3 to [5] study area, new section 6.9.4 “Aspects of IPv6 transition”

5 References

1. IETF RFC 2893 “Transition Mechanisms for Ipv6 hosts and Routers”. August 2000.
2. IETF Draft “On overview of the introduction of IPv6 in the internet” <draft-ietf-ngtrans-introduction-to-ipv6-transition-06.txt>. February 2001
3. IETF RFC 2185 “Routing aspects of IPv6 transition”. September 1997.
4. IETF RFC 2874 “DNS Extensions to support IPv6 address aggregation and Renumbering”. July 2000.
5. “IP Transport in UTRAN Work Task”, TR 25.933, V1.0.0.
6. 3G TS 23.221 V5.0.0. “Architectural Requirements”