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Technology Evolution Framework for 3GPP2 Networks

A White Paper

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REVISION HISTORY

Version	Date	Revision Summary
1.0	2006-08-15	Initial Release

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1. Introduction

3GPP2 is involved in a constant effort to evolve cdma2000®[1] wireless networks to provide better, more efficient service to the customer, and allow introduction of new services. To plan for and guide that effort, this white paper is a high level overview of the 3GPP2 Technology Evolution Framework (TEF) based on projected advances in multiple wireless and networking technologies, including quality of service (QoS), authentication and other security frameworks, over the next ten (10) years. These advances include mobile terminal evolution, radio air interface abilities to carry native IP at ever increasing data speeds, and mobility across heterogeneous and constantly changing access network technologies. The core network evolution will continue to provide a solid framework for control, signaling, QoS, security, and management for voice, data, and video services.

2. Definitions and Abbreviations

Gbps	Gigabits per second
HRPD	High Rate Packet Data
IEEE	Institute of Electrical and Electronics Engineers
IMS	IP Multimedia Subsystem
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
Mbps	Megabits per second
OFDM	Orthogonal Frequency Division Multiplexing
QoS	Quality of Service
RAN	Radio Access Network
TDM	Time Division Multiplexing
TEF	Technology Evolution Framework
WLAN	Wireless Local Area Network

3. Primary Areas of Evolution

There are two major market changes driving the need for this evolution: migration of the current circuit networks to packet networks, and seamless services across multiple access technologies. Moving voice services to a packet network introduces new demands for security handling, quality of service sensitive to delay, unique bearer traffic patterns, and a need to support governmental requirements for lawful intercept and emergency services. Support for seamless services involves full mobility across the different access technologies

[1] cdma2000® is the trademark for the technical nomenclature for certain specifications and standards of the Organizational Partners (OPs) of 3GPP2. Geographically (and as of the date of publication), cdma2000® is a registered trademark of the Telecommunications Industry Association (TIA-USA) in the United States.

and technology independent access to the service applications. The 3GPP2 Technology Evolution Framework (TEF) focuses on multiple areas of improvements that must be anticipated and planned for over the next ten (10) years in the cdma2000 family of networks.

The areas for enhancement include:

- Radio interface technology,
- Radio access network aspects, including RAN architecture,
- Mobility between cdma2000 radio access technologies and other access technologies, and
- Convergence in the core network with other wireless networks, cable networks, and wireline networks.

This white paper explores the current capabilities and future trends in these areas. Additionally, QoS and authentication and other security frameworks are treated separately, since their influence permeates all parts of the network.

4. Radio Interface Enhancements and Evolution

The radio interfaces in use today already support data rates in the 1 to 10 Mbps range. The vision for the future is a set of radio interfaces that support data rates in the 10 Mbps to 1 Gbps range in bandwidths up to tens of MHz. The future radio interfaces will be designed and engineered to provide better and faster support of IP traffic with integrated quality of service (QoS) and improved spectral efficiency. The future cdma2000 radio interfaces will be fine tuned to respond quickly to varying traffic loads, and to protect the data being carried from the dynamic and harsh radio environment. Orthogonal Frequency Division Multiplexing (OFDM) is expected to be the method of choice for several of the future air interface protocols.

4.1 Current 3GPP2 Radio Interfaces

The current 3GPP2 radio interfaces support bit rates in the order of several megabits per second. Ongoing work that includes multi-carrier aspects of the HRPD radio interface will result in peak bit rates approaching 100 Mbps.

4.2 Other Current Radio Interfaces

4.2.1 3GPP Radio Interfaces

In 3GPP, the radio interfaces are roughly comparable with those of 3GPP2, and can be expected to evolve with similar bit rates in the same radio bandwidths.

4.2.2 IEEE Radio Interfaces

The IEEE 802 interfaces are becoming commonly used, particularly 802.11 a/b/g/n, resulting in bit rates in the order of 100 Mbps but with relatively low range. Work on 802.16 is being commercialized and promises to support bit rates near 100 Mbps.

5. Radio Access Network Enhancements

The current radio access network is based on a hierarchical topology typically found in traditional cellular access networks. While this architecture has been successfully deployed to support mobile voice in a number of different markets and for various radio technologies, a number of opportunities exist for improving the architecture. With migration of networks from circuit to packet, the radio access network architecture must accommodate an increased volume of packet-based applications, provide efficient IP packet transport, and support mobility within and between the access networks. Improving this architecture for the support of real-time applications has become a primary concern of network operators and network designers alike.

A number of trends affect the evolution of the radio access network:

- The nature of the backhaul transport network is rapidly changing from the point-to-point TDM connectivity to the any-to-any IP/Ethernet packet based connectivity.
- The type of applications and services demanded by the users are rapidly changing. The RAN must support an increased volume of IP traffic while supporting QoS and service differentiation.
- The proliferation of different air interface technologies is driving the need for seamless inter-technology handoffs.

5.1 Considerations for Future Radio Access Networks

With the advent of wireless packet data services, the volume and QoS requirements of data handled by the network is increasing dramatically, and real-time applications such as VoIP, streaming video, etc., have the potential to overwhelm the existing network models. Hence, the evolved RAN should examine the following standards development approaches in re-thinking the RAN architecture, including:

- Distributed logical topology
- Use of layered end-to-end protocols
- Extensible and backward compatible design
- Interoperable design

The RAN architecture must also take into account mobility and interoperability across different access networks. With this in mind, the core network is becoming more and more access-agnostic. In turn, the access network should strive to minimize access-specific development, and thereby utilize access-agnostic, open standards, particularly IETF based protocols, as much as possible.

5.2 Flexibility in Radio Access Network Topology

Improvements in the access transport infrastructure (e.g. metro rings) allow the architecture to support a more distributed, meshed network as well as the traditional hierarchical model of today. This enables a great degree of flexibility with respect to how the radio access network needs to be designed, allowing for centralization of functions that require it, and for the distribution of functions that are best distributed.

The RAN architecture of the future should allow for the flexibility of topology to fit the needs of the operators. That is, the logical topology should allow the physical topology to be as hierarchical or as flat as required by the functionality that needs to be delivered by the network.

6. Intra/Inter-Access Technology Mobility Evolution

Migration of the bearer traffic from circuit to packet networks is a critical market driver of the intra/inter-access technology mobility evolution. Current voice traffic patterns keep calls within a local calling area hubbed in a star topology connected to an aggregation point (today's MSC). Voice service handling in a new environment needs to address the issues of network topology, maintain the quality of service equal to or better than the circuit network, and provide seamless handoffs that are transparent to the user's experience.

The days of a mobile terminal using only one radio access technology to take advantage of the vast array of services that are already available on the Internet are gone. Commercial mobile terminals already are available that support 3G packet data, circuit switched services, and one or more IEEE 802.11 radio interfaces. Chip technologies continue to advance, and the expectation is that a single mobile terminal will support perhaps three or four different access technologies – some of them non-radio.

For example, it is not unreasonable to assume that a single terminal would support some combination of cdma2000 1x, cdma2000 HRPD, IEEE 802.11 (WiFi), and 100 Mbps Ethernet. This terminal would be able to take advantage of advanced HRPD networks, legacy 1x networks, WiFi coverage in buildings and metropolitan areas, and wired Ethernet access in a docking station at home or in the office.

The common denominator for all of these access networks is IP. It should be noted that legacy cdma2000 1x circuit oriented networks will provide the ubiquitous background coverage for some period of time until these other wireless access networks provide continuous coverage. It is anticipated that IP packet transport is provided not by just one access network technology, but by several. This mandates smooth mobility across these various access networks both while idle and while services are being delivered.

Current networks have solved the problem of mobility across multiple base station sectors. However, there are still problems at higher protocol layers in keeping the bearer channels that connect the terminal to the Internet flexible in support of the lower protocol layer mobility. Solutions will be found that support not only improved mobility within a given access network, but also improved mobility across different access network types.

This improved mobility will result in smooth, even delivery of services over this native IP transport environment. Bearer traffic will be optimally routed to reduce the cost of backhaul and interconnecting networks. Signaling will support both operator needs and customer desires in a blended manner.

As an example of what a subscriber can expect, consider the person whose terminal device is connected to a small docking station at home. The terminal is not only charging, it is connected to a fiber optic or cable based service that comes directly into the person's home, providing 1 Gbps service or greater. The terminal alerts the person to an incoming video call, and the call is answered by voice activated command as the terminal's owner finishes preparing breakfast. After a few moments of discussion, the terminal is lifted from its docking station and the owner walks to their car to drive to work. The video call continues over WiFi service based in the home. Placed in the car's docking station, the call continues, but has transitioned to HRPD radio coverage. As the person arrives at their office, the call transitions to a corporate WiFi access network as the terminal enters the building coverage, and transitions once more to wireline Ethernet access as the terminal is placed into a docking station in the person's office. All of this is done seamlessly with minimal to no loss of data as detected by the human eye and ear. Mobility mechanisms modify and move the signaling and bearer traffic in a continuous and transparent process as the terminal moves into and out of coverage of various IP-capable access networks.

6.1 Current Inter-Access Mobility

The current work of 3GPP2 has been to enable the use of IEEE 802.11 wireless local area networks (WLANs) in addition to the other cdma2000 radio interfaces. This is in parallel with similar work in 3GPP. Idle handoff mobility across these technologies has been progressed, and now work is completing on active handoff mobility across these radio technologies.

6.2 Future Inter-Access Mobility

Customers are going to need and demand the ability to hand off active sessions (voice, video, and data sessions) across wireless, wireline, and cable access technologies. It will no longer be enough to have only a wireless service. Instead, there will be a demand for integrated services that will allow mobility across all available access technologies.

6.3 Support for IPv4 and IPv6

The lack of availability of IPv4 addresses is inhibiting the evolution of IP-based services. It is expected that movement to IPv6 will predominate, but that IPv4 will also need to be supported.

6.4 The Role of Mobile-IP

It is expected that Mobile-IP technology will play a large role in future mobility. Mobile-IP has the capability to move traffic bearers seamlessly across diverse access networks. Solutions that will be developed to support mobility of active sessions across the variety of wireless, wireline, and cable technologies are expected to support both IPv4 and IPv6.

7. Converged Core Network

A converged core network that supports multiple access technologies brings the promise of a single set of services that can support users across these technologies in a seamless manner. Neither the user nor the service should have to be aware of the access technology. Mobility across these access technologies should be seamless – uninterrupted during active sessions and always accessible regardless of technology. A common service application layer allows for interworking of session-based services and other types of services. Combinations of web page browsing, VoIP sessions, and non-session-based streaming downloads of data can be used to build valued services for the user.

Using the example video call that transitions from home to car to office in the previous section, consider the work required in the core network. That core network is centered on the IMS. Beyond its roots in support for the 3GPP and 3GPP2 wireless access networks, IMS improvements are needed (and are already under way) to support all IP access networks, including wireline and cable networks. In Europe the fixed network IMS is being defined by the ETSI TISPAN committee based on 3GPP IMS.

Support and improvement of existing services, as well as rapid deployment of new IP-based applications are key requirements on the core network. IMS is the framework and foundation structure that will support those services. IMS must be evolved and improved to handle the transitions between these various environments that the terminal finds itself in. While maintaining a certain level of independence of the access network, IMS must also be able to cope with the changing access network capabilities in terms of capacity and speed.

While IMS is expected to be the future framework for the core network, current mobile services are non-IMS services. Such non-IMS services will continue to expand in capability and value and will remain an important aspect of the service offerings of these networks. Future evolution of the core network will need to accommodate both IMS and non-IMS service environments.

Some applications may require extremely high data rates, and may need to be informed when such data rates cannot be delivered so that they can adjust their service delivery. Other aspects of service delivery such as charging variations, subscriber preferences, security, QoS, and operator policies must be constantly juggled by IMS in support of the applications providing those lifeblood services to the subscriber. These are challenges that must be addressed as the highly mobile, heterogeneous environment develops and evolves.

7.1 Common IMS

IMS is expected to provide the control structures for the foreseeable future. Cooperation on IMS standards development has led to a unified development of IMS that will support the variety of access networks across 3GPP2, 3GPP, IEEE 802, and other standards bodies. IMS is the foundation on which operators are expected to build services and their futures.

7.2 Strengthening the IMS Platform

As initial commercial deployments see more and more use, the IMS community will learn lessons and discover new and improved ways of doing things that improve the overall structure of IMS. Optimizations and improvements will be found that will be worked cleanly into the overall architecture. Network operators will take advantage of these improvements to create even newer and better services, while driving down the overall costs of providing telecommunication services.

8. System-Wide Capabilities

There are various capabilities that have a pervasive influence on the design and function of all areas of the network. The most important of these system-wide capabilities are described below.

8.1 Security

Security is a key element of network services. The security function is a critical requirement of reliable service delivery and business continuity in all IP based networks. Advanced security mechanisms and technologies will effectively defend network functions from attacks, allowing mobile operators to deploy secure, resilient networks, and to protect their services and subscribers. Actions are also needed to defend the mobiles from attack from the Internet and other mobiles. Network firewall configuration and control is designed to address such protection issues. In addition, VoIP traffic will need special handling separable from Internet access traffic.

Authentication is also a major security aspect to ensure that the person receiving services and the network providing the services are certain of the identity of the other party. Online banking, e-commerce, and confidential communications will grow only when the consumers feel comfortable that they are certain of the identity of the service provider.

8.2 Quality of Service

Aspects of quality of service address the market needs of handling previous circuit traffic in a packet network environment. Special handling of time-sensitive services requires attention to end-to-end QoS signaling. Route optimization and header compression contribute to maintaining or exceeding the circuit QoS that the user has come to expect. In order to deploy future services, e.g., VoIP and streaming video, an “end to end” Quality of Service (QoS) solution will be a requirement. Users have become accustomed to continued service improvements and will demand high quality service from the networks that will be deployed. End-to-end QoS will be a pervasive influence on the design of all aspects of the future networks.

9. Summary

As the work of 3GPP2 continues to evolve for the future, the following areas should be considered:

- Radio air interface abilities to carry IP more natively and at ever faster speeds with low latency;
- Radio access network flexibility to support current and evolving topologies;
- Access network mobility across heterogeneous and constantly changing access network types; and
- IMS improvements to continue to provide a solid framework for the development of services.

The goal is faster IP data, better QoS, heterogeneous and transparent mobility, and a solid structure for the support of future services.