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3RD GENERATION PARTNERSHIP PROJECT 2
"3GPP2"

3GPP2 Vision for 2010 and Beyond

Editor

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Revision History

Revision	**Description of Changes**	**Date**
Rev 0 v1.0	Initial draft	2 April 2009
Rev 0 v2.0	Update for 2010	24 June 2010

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FOREWORD

This foreword is not part of this document.

This document was prepared by the Third Generation Partnership Project 2 (3GPP2).

1 INTRODUCTION

1.1 Scope

This document contains the 3GPP2 vision for the time frame 2010 and beyond.

It describes:

- New and enhanced services and applications
- Network and user equipment capabilities that meet the new and enhanced services and applications
- Candidate radio technologies and networks on which such capabilities are desired
- Roadmap(s) and time-lines of the new services and applications.

The key element of the 3GPP2 vision is to provide connectivity and support for access to open Internet services and applications.

The content of this document aligns with the views expressed by the 3GPP2 Future Directions and IMT Advanced Workshop held in Osaka, Japan in May 2008 and subsequent updates.

Ongoing updates to specifications are not included in this document.

1.2 Terminology

1.2.1 Acronyms

TERMINOLOGY	ACRONYM & ABBREVIATION	DEFINITION
CDMA Developers Group	CDG	
Computer and Communication	C&C	
evolved HRPD	eHRPD	Referring to the modifications in the access and core network primarily designed to allow inter-technology interworking with E-UTRAN.

HRPD-Enhanced		Referring to the radio interface modifications designed to improve system efficiency and network capacity.
Network Address Transliteration	NAT	
Next Generation Mobile Networks	NGMN	
Packet Switched Video Telephony	PSVT	
Supervisory Control and Data Acquisition	SCADA	A computer system for gathering and analyzing real time data.
Voice over Data	VoD	
Voice over IP	VoIP	
Web-2.0	n/a	A term for describing changing trends in the use of World Wide Web technology and web design that aims to enhance creativity, secure information sharing, collaboration and functionality of the web, by proliferation of interconnectivity and interactive web-delivered content.

1.3 References

[1] Ed Tiedemann et al, “Final Workshop Report”, 3GPP2 Steering Committee SC-20080728-009_3GPP2_Future_Workshop_Report.ppt, Osaka, May 2008.

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[3] ABI Research “M2M Market Data”, 1st Qtr, 2007.

[4] TR 22.868 v8.0.0, “Study on Facilitating Machine to Machine Communication in 3GPP Systems”, 3GPP, March 2007.

[5] H. Viswanathan et al, “Enabling M2M communications in HRPD”, 3GPP2 TSG-C C30-20080616-012, June 2008.

[6] NGMN, White Paper "Next Generation Mobile Networks Beyond HSPA & EVDO", Version 3.0.

2 HIGH LEVEL VISION

3GPP2 will strive to develop specifications that deliver the best voice and data communication services as measured by performance, network and air interface efficiency, and complexity.

The vision for 3GPP2 in the 3-5 year period from 2010 and beyond is:

1. Enable highly efficient wireless communication technologies of the cdma2000® family by evolving the technologies to maximize use of existing deployments of cdma2000-1X and HRPD;
2. Deliver with cdma2000 1x-Enhanced the highest voice capacity per MHz of spectrum among any known systems, with the goal of more than tripling that capacity relative to the currently deployed cdma2000-1X;
3. Deliver with HRPD- Enhanced the most spectrally efficient wide area wireless mobile packet data system;
4. Position 1X- Enhanced and HRPD-Enhanced as critical long-term components of evolving wireless technology platforms worldwide.

These goals are consistent with the often-expressed vision of operators, including CDG (www.cdg.org) and NGMN Alliance (www.ngmn.org). Annex 1 codifies the CDG "Operator Priorities for cdma2000 1x and HRPD Enhancements". NGMN Alliance is an international group of operators that states "… existing systems, including planned enhancements such as HSPA and EVDO Rev. A […] are expected to keep [these] platforms competitive for some time to come."

3 TRENDS AND DIRECTIONS

3.1 Technology Trends

Currently, the wireless industry is characterized with some general trends, which are outlined as follows.

Volume of traffic carried in wireless networks is increasing, even in developed markets with a high degree of penetration (percentage of populace that subscribes to wireless services). There are several reasons for this, the principal one being that affordability of services continues to improve, in particular for voice service.

In developing countries, this improved affordability allows more people to become qualified for wireless service subscription. Penetration is rapidly increasing for wireless systems, as wireless is seen as the fastest and most effective technology to improve communication infrastructure in those countries. Subscription growth is driven primarily by those developing markets. The historical trends and projections are for steady increases.

In developed cellular networks, the number of subscriptions may not be increasing as rapidly as in the past several years since penetration is approaching saturation levels in many countries. Though customer rate of increase may be tapering off, minutes of use per subscriber are growing.

In summary, there is an increase in volume of traffic per user, as well as overall traffic volume.

The number and variety of devices that have wireless connectivity continues to increase. There is an increased competition among device manufacturers at all tiers. At the high end, as wireless data services become more popular, new competition is arising from manufacturers which traditionally come from information technology and computers/software industry segments. At the low end, global competition is increasingly at play, as manufacturers from an ever-increasing number of countries introduce their wireless products.

End-user device capability continues to improve, in particular in terms of multimedia support (voice, audio, video, etc.). Devices are more capable in other aspects, including human-machine interface, display, camera, location, sensing capability (e.g. accelerometer support), increased storage capability for multimedia, e-mail, etc.

The share of Internet traffic being carried by wireless networks is increasing. This growth parallels increased traffic volumes for voice services described above, but it's even more pronounced. These trends will likely encompass newer multimedia services (e.g., video), as their user acceptance increases. The rapid growth of data services is competing for the network capacity currently used for voice service.

The traditional methodology for expansion of network capacity (e.g. cell splitting) remains challenging for operators, as cell site acquisition in many communities becomes ever more difficult. Complexity of other associated activities such as power, backhaul, etc. is also a factor. Network expansion for growth must deal with these constraining circumstances as trends such as unlimited minutes of use (data is already unlimited in many markets) drive the need for efficiency and increased network capacity.

It is essential to maintain and enhance cdma2000 spectrum efficiency and network capacity, so that operators can cope with the trends outlined above, and remain capable of serving customers and growing subscribers.

3.2 Industry Trends

The global wireless industry is increasingly cooperating in many aspects of standardization and technology, as well as on the operational aspects. This is helping create a large wireless eco-system required for the industry to move forward.

Packet-data communication is a common foundation for the industry going forward. Internet protocols defined by IETF ensure convergence of various forms of access, including wireless, and compatibility of applications.

Fixed-Mobile Convergence is occurring partially as a result of the prevalence of the Internet as the underlying technological building block. The advent of femto cell systems is an example of the result of such developments. The use of femto cells has a potential to expand considerably, and be an element in assisting operators to manage traffic growth.

Another important industry trend is network openness to developers of end-user devices and applications, promising to accelerate innovative uses of wireless systems. Regulators may recognize that network openness and technology neutrality might serve to bolster the basic mission of regulatory bodies, which is to assist the populace in times of emergency, and to allow wireless networks to play an unimpeded role in advent of an increasing array of every-day activities of users.

3.3 General Direction of 3GPP2 Specifications Developments

The high level vision of 3GPP2 technology developments can be summarized as follows:

- System capacity improvements that allow operators to cope with increased demand for voice services.

- Efficiency of voice services is critical as growth of demand for data services accelerates and occupies an ever-increasing percentage of radio transmission resources.

- Data transmission efficiency is likewise increasingly important in order to lessen the impact of traffic growth.

- Network capacity, robustness, and resilience will be continually improved to handle such substantial increases in traffic during calamitous events. This is driven by public safety and security concerns which are of increasing importance for wireless network use. Regulators and the public are getting accustomed to relying on omnipresence of wireless communication in assisting at times of crises, and in everyday public safety.

- Femto cells may become increasingly important in providing an alternative to traditional network build-out, and offering increased network robustness. Femto cells, micro cells, pico cells and repeaters must work seamlessly with the macro network.

- The operator requirements for efficient network management and operation amplify the need for Self-Organizing Network (SON).

4 Services, Applications and Network Enablers

Connectivity in a user's every-day activities is essential, and something many consumers have come to expect. Increasingly, wireless communication devices are becoming central tools enabling constant connectivity, or an indispensable capability for other types of devices whose primary purpose is not necessarily voice communications, e.g. music players.

Younger consumers are probably most innovative among wireless communication users. They appreciate connectivity on-the-go, as social networking enters every-day lexicon, thanks to these young trendsetters.

Alluding to the version-numbers that commonly designate software upgrades, the phrase "Web-2.0" hints at an improved form of the World Wide Web, though in reality the fundamental Internet technology is unchanged. "Network as platform" mantra of computing in Web-2.0, allows users to run software-applications entirely through a browser, which enables applications to evolve on the web, with little or no need to change client software.

Collaborative Web-2.0 is perhaps not yet in every-day use, however, its development indicates that there is an on-going evolution of the communication service platforms, which will play an increasing role for wireless. Web-2.0 includes many convergent components of networking, including collective knowledge and sharing (e.g. Wikipedia), podcasting and media sharing, blogging, e-commerce, web-based messaging and archiving, etc. A general observation can be made that all these web-based services are increasingly interactive, with ever-higher demand for low round-trip delay. For example, a web based e-mail service demands user experience that is akin to a PC-based (local) e-mail application to be competitive in terms of user experience. Thus, the underlying wireless technology must have extremely low round-trip latency to make it all possible. This is one of the key requirements for enhancements for HRPD-Enhanced.

HRPD and cdma2000-1x can be envisioned to be embedded in many devices, not just cell phones. This trend has already started with convergence of computers (laptop is migrating toward palm-top) and communication, and will be amplified with the modern trends with applications and services such as those using Web-2.0 as a platform.

4.1 Service Vision

The mobile communication service has been developed with the purpose of providing communication between users and getting basic information in a mobile environment at a level that can replace existing wired phone service. However, as user demands for diverse multimedia services increase, and as technologies to provide these services rapidly develop, high quality service infiltrates every aspect of our lives and provides convenience, stability and variety of contents, in addition to rapidly changing human lifestyles.

The next generation mobile communication system will provide not only the existing communication services, but also a variety of services in a mobile environment that extends over all areas of everyday life. They include:

- Business and commerce related services (banking, shopping)
- Health related services (telemedicine, health checkup)
- Safety related services (emergency communication, public safety, disaster management)
- Leisure and entertainment related service (video, music, game)
- Education related services (remote training)
- Location and transportation related services (LBS, travel)
- Lifestyle related services (personal assistant).

4.2 Service Requirements

The following is a summary of the characteristics of next generation services expected by the user:

- High-speed and Delivery: In the past, services such as video telephony, streaming, and VoD, were only possible through a wired network because of the difficulty for existing mobile communication to provide enough transmission bandwidth. These services are now also enabled in wireless mobile environments, wherein high speed data transmission will be provided through high quality multimedia and voice call service.
- Context Awareness and Adaptation: Smart units with Computer and Communication (C&C) abilities can support circumstantial recognition functions. These functions detect dynamic environmental changes and provide the user with services relevant to the specific circumstances. These functions operate by going through a recognition and deduction process, followed by a collection and exchange of circumstantial data (including data of the user and surroundings that can be used at the time of user interaction). This function is subject to user privacy constraints.
- Seamless Service Continuity: Based on the development of a variety of wireless communication technologies, the next generation mobile communication systems will provide:

    - Service continuity using different devices
    - Service mobility between different networks
    - Service mobility between applications on a single device.

- Interworking and Convergence: The rapid development of Internet and data communication technologies together with the integration of wired and wireless communication systems enables the convergence of the following:
    - A variety of communication networks
    - A variety of digital equipment
    - A variety of application services

  Examples of such services consist of a variety of usage scenarios, including:
    - Communication and finance
    - Communication and distribution
    - Data communication and electronic appliance

- Personalization: Lifestyle enhancing services that are adaptable to the individual needs within diverse societies are expected to be customized, based on individual profiles and preferences.

- Always-best Connection: In a wireless environment where a variety of communication technologies coexist and service domains overlap, end-to-end connections can vary dramatically. The system should provide the optimal connection for peripheral networks, equipment and services with regards to the terminal location, transmission environment, QoS requirement, and subscriber preference.

- Security and Privacy: The system should ensure communication security and user privacy in any location for a variety of applications.

4.3 <u>Service Classification</u>

The classification of services into voice, data and broadcasting is inadequate for the next generation of mobile communication services. The following six service categories are defined based on service usage:

- Point-to-point Communication Services

- Personalized Infotainment Services
- Enterprise/Business Services
- Education Services:
- Public Services, including Safety and Disaster
- Health Care Services

These service categories are defined as follows:

- Point-to-point Communication Services: Traditional voice communication service has been used for direct communication between users (user-to-user communication). This service has expanded to text messaging and other non-voice services (e.g. PSVT). Such services will be further enhanced by additional information, such as mobile positioning that serves to enhance application capability. Furthermore, the point-to-point category includes basic communication to support all other service categories.
- Personalized Infotainment Services: These individual information activities include news, movies, feature stories on leisure and hobby activities, travel information, etc.
- Enterprise/Business Services: Information services tailored to the business community.
- Education Services: Information services tailored to the education and training.
- Public Services, including Safety and Disaster Recovery: This category includes all services provided by national, regional or local government, including disaster management and public safety services.
- Health Care Services: The number of such services will expand as more attention is focused on health and wellness.

4.4 Service Enhancements

4.4.1 Voice Enhancements

The two primary areas of voice service enhancements are capacity and voice quality. In addition to that, VoIP transition is a major development, which should be executed well by the cdma2000 community.

3GPP2 has developed a solid voice platform in the EVRC vocoder, including its wideband component. EVRC is flexible, with features such as rate control in

Revision B and later, and superior MOS performance. However, it is the deployment of these Revisions of EVRC, which will result in increased network capacity and/or improved voice quality. Deployment of VoIP, which will enable wideband codec in commercial use, will be a market-changing event. 3GPP2 should be fully engaged in these deployment events, and ensure that any standardization support goes hand-in-hand with these deployment, if needed.

An important goal for the organization is to support improved end-to-end voice quality. To that end, proliferation of broadband EVRC over VoIP, with these same technologies gaining penetration in fixed networks, should be supported by concrete efforts in 3GPP2.

Additional aspects of voice quality include minimizing call setup delay, and availability of supplementary features, among others. For VoIP, call set-up delay performance goal should be the same or better than for CS calls. With the Common IMS initiative, 3GPP2 must ensure that IMS supports VoIP over HRPD well.

4.4.2 Packet Data Enhancements

The key performance enhancements for packet data support are further reductions in the latency of packet transport across cdma2000 radio access and core network, and the assurance of low signaling delays, so that call setup and handoff times are minimized.

In terms of feature support, expansion of efficient roaming support is also an important objective. The other areas of enhancements can be grouped into gateway and core network enhancements:

Gateway network enhancements include:

- QoS management
- Low-latency signaling for session and handoff management
- Minimized and flexible signaling hierarchy architecture
- Support for multimedia services
- Multicast capabilities across Radio Access Technologies (RATs)
- Policy enhancements to support heterogeneous RATs
- Firewall requirements
- Support for a variety of access security capabilities
- Femto system enhancements (see section 6.4)

Inter-Technology Inter-working Enhancements (see section 5.9):

- Protocol enhancements for seamless mobility
- Context transfer schemes for handoff optimization

Core network enhancements include:

- Policy management across a variety of access technologies and domains
- User profile driven service discovery support
- Enhancements for PSTN emulation and simulation (e.g., adaptation to all-IP followed by native all-IP)
- Accounting enhancements for different access technologies and charging metrics
- OSA enhancements for third-party applications
- Security enhancements
- Codec negotiation support
- Seamless mobility across core networks
- Common IMS

One of the objectives of packet data architectural enhancements in the upcoming period should be to develop solutions which will offer universal mobility between a variety of access networks, making it simple for an operator to introduce a new access network and to migrate from one access network to another. One possible approach is to design the packet data architecture in such a way that no changes in the core are needed in case an operator introduces a new access in the network.

A major stride forward is being made in this respect with the definition of the Evolved Packet Core (EPC) by 3GPP. Using a dual gateway approach, the ability is provided to have a common core and to attach multiple access networks, including both wireline and wireless access technologies. The cooperative work between 3GPP2 and 3GPP to attach the eHRPD access network to EPC is representative of this advancement. Network evolution from tightly coupled with HRPD rev A, to tightly coupled with HRPD rev B, to dual gateway (see Figure 1) with eHRPD rev B may be an attractive path for some operators.

The current mobility solutions were designed with an objective to allow mobile terminal movement from one base station to another, i.e. the fundamental assumptions are:

- Unchanged access technology
- The main service used by the subscriber is voice

Inter-technology mobility solutions that were subsequently developed built upon that basic concept, defined since the second generation network design. However, the scenario of mobile networks is much more complex now, with a plethora of different accesses, each with its own different characteristics, and with terminals capable of running many different applications, each with its own requirements.

Based on this consideration, the future mobility architecture should have as an objective the possibility for the terminal to be connected to any type of access, even simultaneously, and to move packet flows between connections, depending on radio conditions, user's preferences, operator's policies and application characteristics, be it on the same access technology, or between different ones. This type of mobility is referred to as universal mobility. One option is for the terminal to trigger this universal mobility, based upon the connectivity options available to it at any given time, and in accordance with its preferences, subject to controls imposed by the operator. An example of simultaneous multi-technology access is voice service on HRPD Rev. A and web browsing on WLAN.

The three mobility architecture options are illustrated in Figure 1.

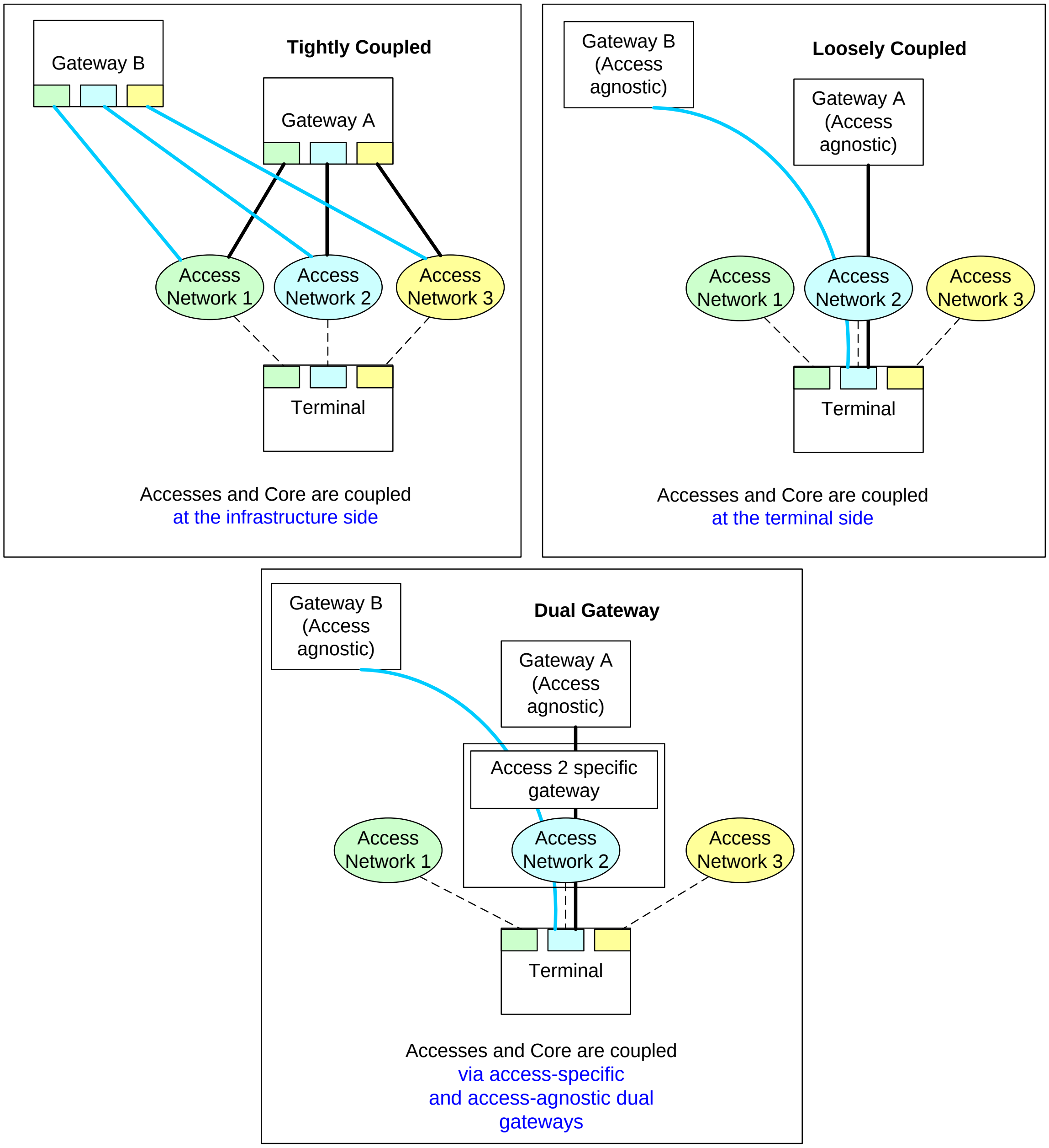

Figure 1: Mobility Architecture Options

In the tightly coupled architecture, the packet data core network gateway (GW) must be coupled to each of the supported access network varieties individually. The gateway is not access agnostic. The introduction of a new access implies changes, in order to be adapted to the core, and possibly changes to the core, in order to handle access-specific procedures and protocols.

A dual gateway architecture provides an answer to this issue by creating an access agnostic gateway and an access specific gateway to handle the details of specific access networks. This separation of the network agnostic and network specific functions into two gateways provides flexibility supporting multiple business models, multiple access networks, both home and local services, and controllable billing, e.g., for prepaid users.

In the loosely coupled architecture, every mobile is handled exactly the same way, be it a roamer or a local subscriber. In contrast to that, with the tightly coupled approach, if a roaming mobile needs to access its home gateway, that home GW must be connected to the local access network, and the access network must be able to handle the logic of connecting the mobile to the correct gateway.

The objective of the loosely coupled architecture is to make the gateway access technology agnostic. This can be achieved by limiting the access-specific coupling to the lower protocol layers between the terminal and each of the access technologies it supports, and building an access agnostic overlay that spans directly between the terminal and the gateway. This effectively achieves the binding of the terminal with the core independently from the accesses. The result is a simplified access system, having moved some complexities to the overlay, and each access variety simply providing an efficient local IP connectivity. This separation of core and access systems is achieved by a client-based mobility protocol.

The loosely coupled approach provides arbitrary connection of serving access network to core network which creates additional flexibility and more complex business models.

There are a number of benefits of the tightly coupled approach:

- An operator has tight control over which networks the mobile device is allowed to attach to.
- Inter-access technology mobility can be provided in a controlled manner.
- All backhaul is under the control of the operator.

The benefits of the dual-gateway approach are:

- A single core network architecture supports Common IMS and attachment of multiple access network technologies.
- Both wireless and wireline technologies are supported.
- There is a single way for operators to control Policy and Charging across roaming situations.

- Service limits, e.g., for prepaid subscribers, can be uniformly enforced across access networks.
- Inter-technology mobility can be supported.
- The ability of a misbehaving mobile to disrupt both access and core network operations is minimized.
- It is feasible for the terminal to operate on multiple accesses simultaneously, and to have mobility services between them.
- Core network evolution can proceed independently from access network evolution and vice versa, enabling each to develop at its own speed.
- Mobility between fixed/nomadic and truly mobile accesses are uniformly handled.
- An operator can offer services from any access network with which the operator has a business relationship.
- Offloading traffic to less precious accesses can be more easily implemented.

There are a number of benefits of the loosely coupled approach:

- Applications can be decoupled from specific accesses by the uniform overlay.
- It is feasible for the terminal to operate on multiple accesses simultaneously, and to have mobility services between them.
- Core network evolution can proceed independently from access network evolution and vice versa, enabling each to develop at its own speed. Thus, it is not necessary for access systems to directly link with the core GW and with each other. There is no need to deploy a new core network when a new access type is introduced, and vice versa.
- Access systems can be simplified, as some key functions are moved to the overlay.
- Mobility between fixed/nomadic and truly mobile accesses would become more prominent.
- An operator can offer services from any access, even if not under its control.
- Offloading traffic to less precious accesses can be easier implemented.

- Enabling deployment of multiple access systems with lesser mutual dependency.

4.4.3 Mobile Broadcasting Services

The following Mobile Broadcast Services should be considered:

- Mobile broadcasting presents an opportunity for substantial future innovations in wireless services, in addition to its use as a tool for emergency management in such applications as wireless alerts in cases of potential natural disasters.

- In regards to emergency broadcast enhancements, the standard should allow good battery standby time once these services are put in operation.

- For multimedia Broadcast and Multicast Service (BCMCS), clip-casting security should be studied, to allow subscription-based service. Clip-casting is broadcasting of multimedia contents, usually of short duration, e.g. songs, music videos, news items, etc., for storing on the target mobile device, with the intent of later playback.

- Multicast messaging and group paging can be used for the purpose of addressing emergency response teams in the context of priority service support. They are an efficient way to distribute messages to a user group, as opposed to individual message to each member of the group. 3GPP2 should enhance existing HRPD mechanisms with a cost efficient method to enable broadcast/multicast messaging applications.

4.4.4 Video Telephony and IPTV Services

PSVT has already been standardized in 3GPP2. However, the following should also be considered:

- Multimedia streaming, including video and audio (music), is a client/server web application that runs well over existing HRPD networks. 3GPP2 should investigate any required performance enhancements or supplemental web services for future applications in this area.

- IPTV is very similar to multimedia streaming. The principal distinction is multimedia codec formats (e.g. support of HDTV or Blue Ray format), and the associated accounting model. Authorization and charging may need to be addressed.

- As in the case of PSVT, femto cell deployments have the potential to enable IPTV, using femto cells as multimedia hubs in households. With femto cells, IPTV offers the potential for innovative and disruptive services for wireless operators. In its standardization work, 3GPP2 should account for such potential development, though this is not expected to affect the work plan in a direct sense.

4.4.5 Location Based Services Enhancements

Geographic location capability of cdma2000 is very strong in comparison to competitive location technologies in wireless devices. Further enhancements may be considered in the following areas:

- In addition to Assisted GPS (A-GPS), owing to synchronized network operation, cdma2000 has at its disposal Enhanced Forward Link Trilateration (E-FLT) techniques. Augmenting A-GPS in indoor and urban canyon environments when GPS satellite visibility is limited; this technique helps make cdma2000 location sensing extremely accurate and reliable. This robust basic solution and the technological lead it provides in the marketplace must be maintained and further improved.

- Emergency location (e.g. E-911 in North America) has proven to be a valuable public assistance capability, so much so that regulatory agencies are recognizing its value, and are aiming to further improve it by tightening accuracy requirements. Whereas previous accuracy requirements were on an aggregate statistical basis (throughout the operator's network), regulatory trend is to further improve accuracy requirements, and to make them applicable on a more granular basis, e.g. down to county average, and furthermore to municipality, postal code, even possibly city block in the future. The value of FLT techniques is thus becoming obvious, since the greatest accuracy challenge is in dense urban environments, where many users are in urban canyons or indoors in high-rise buildings with poor penetration of GPS signal. 3GPP2 should strive to further improve these techniques, taking advantage of technological developments such as Highly Detectable Pilots, and broadband sampling capability trends in mobile terminals, which allow improved PN phase resolution, harmonic interference reduction, triangulation efficiency enhancements, etc.

- Femto cells are also important components of future, more accurate location service capabilities. High quality femto cell location standards must be developed in 3GPP2, so that femto cells meet Emergency Calling accuracy requirements, and their deployment positively contributes to the pending accuracy requirements on a more granular basis, where it counts most – indoors. Additionally, future femto cells are expected to have altimeter built in, so that vertical position can also be provided to emergency personnel.

- As VoIP deployments approach, Emergency Location native to HRPD must be enabled, as opposed to relying on cdma2000 1x.

- Making location services work with minimum impact on battery life is of paramount importance to commercialized location based services. Any standards impediments to that underlying standing requirement should be addressed. As mobile terminals become more capable, commercial location services will increase in appeal. For example, trends such as improved display technologies, increased memory for storing maps, faster data rate capabilities to download maps and current traffic data, additional sensors (e.g., odometer, accelerometer), etc., all have the capacity to supplement service offerings for location services.

- Network openness to run any application on a terminal will help to enhance location based services. With web-based maps that are easy to use and integrate into applications, communication services with the location component are potentially on the verge of mass market take-up.

4.4.6 End-to-End Priority Services Enhancements

Wireless Priority Services (WPS) have been developed and they are already deployed for circuit-switched voice service on cdma2000 1x. For the future:

- In the next phase, aimed at VoIP, video, and packet data, the intent is to extend and broaden this capability, as well as to refine and enhance it relative to its predecessor. 3GPP2 has started work on this project by developing requirements for Multimedia Priority Services (MMPS). In the upcoming period, 3GPP2 should continue to support this effort.

  The project envisions five (5) levels of priority, from the executive branch down to disaster recovery respondents. Privileged access and use of network resources is granted to priority users at times when ordinary users are blocked from accessing the network due to congestion or incapacitation of resources.

  To work under all conceivable scenarios, MMPS with its associated priority capabilities must be supported throughout the network and at any and all potential blocking points. Thus numerous mechanisms must be developed, for example capability to queue up the users' MMPS invocation requests for network resource, rather than blocking them in case of congestion.

  Strong security measures must exist to ensure that MMPS is not abused by fraudulent users.

- Once developed and supported in the networks, this capability can be extended to the business and private sector, without jeopardizing its intended purpose. It would allow definition of premium service for high-end business users. These users would have preferential treatment by the network, with differentiated Grade of Service (GoS). High-end users would experience low blocking rate during busy hour, and better data traffic performance (e.g., low packet drop rate, queuing for resources, etc.), while low-end users would have opposite experience. Off busy hours, such differentiation is inconsequential.

- User differentiation by GoS will become one of possible tools to further manage network growth. GoS offers ways to differentiate users by blocking rates they experience. This approach may be appealing in some markets, but care must be taken that consumer reception is well understood before launching such capabilities, perhaps combining it with minute buckets.

- GoS differentiation is related, but different than QoS. This is illustrated in the following two figures.

Figure 2 is a pictorial illustration of flow-based QoS. Flows belonging to different applications with different delay tolerance are differentiated in their QoS treatment. The primary objective of flow-based QoS is to efficiently allocate network resources for each application, commensurate with that application delay tolerance, thus maximizing network throughput. At any given time, network resources are equally shared by two users each running an application with same QoS requirements.

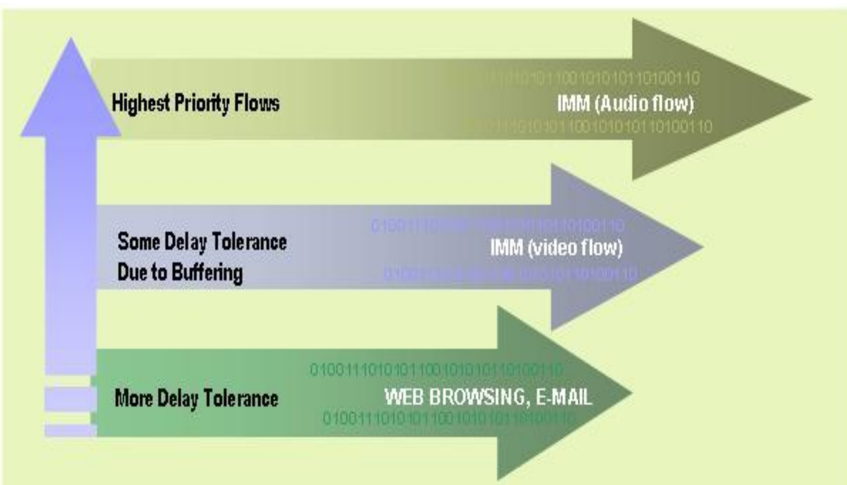

Figure 2: Flow-based QoS Differentiation

In contrast to that, GoS differentiation can occur among two users running the exact same application. When network resources are reaching the limit, the user with lower priority may experience dropped packets and more sluggish performance compared to a user with higher priority. This is illustrated in Figure 3. The differentiation is based on the user's subscription level (Executive, Premium, Standard), where user subscription profile determines transmission resource allocation, while trying to keep them within general constraints of delay tolerance for a given application, until resource exhaustion. Admission differentiation is also applicable.

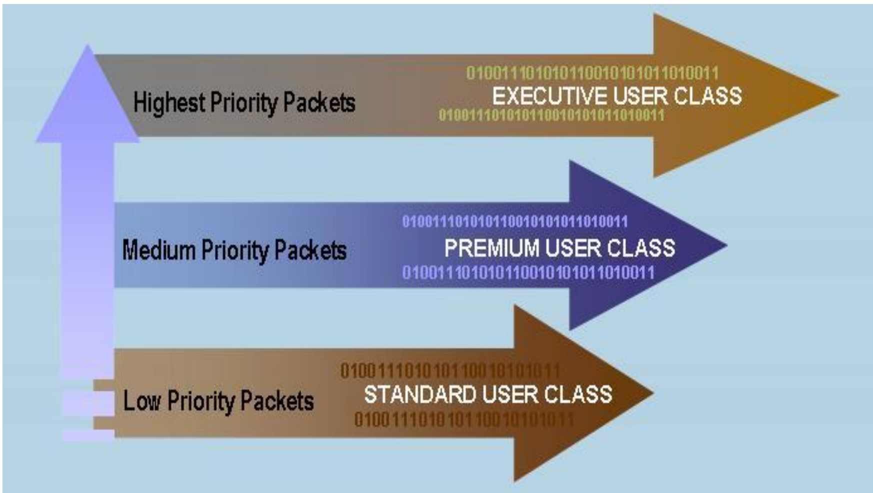

Figure 3: Grade of Service Differentiation

<u>4.4.7 Advanced Network and Services Management (Self-Organizing Networks)</u>

One of the most important trends in the wireless communication industry is advancements in network management, and the accompanying management of services. The goal of these advancements is to make network configuration as automated as possible, ultimately to have the networks self-configure. Thus the term Self-Organizing Networks (SON) entered the lexicon.

Nowhere is the goal of SON more important than in the case of femto cell systems. There are two principal reasons for that.

- Activation of a femto cell must be simple for a typical customer, including those who do not posses much technical know-how, and those who expect ease of use of a consumer product such as femto cell.

- Millions of femto cells are expected to be deployed on a large operator's network, often with a rapid pace of activation. It is operationally less efficient for the operator to dedicate human resources in their operations divisions to support this by way of a manual process.

Thus from the operator's perspective, the process should be "no-touch", with rare cases of manual intervention and trouble-shooting.

Upon acquiring the femto cell by the customer, and exchanging basic information with operator customer representative, which should be no more extensive than cellular phone activation, the rest should be largely automated.

Femto cell activation should be an easy set of steps of connecting the femto cell hardware to the fixed broadband outlet, applying power, and having the femto cell operate within a few minutes thereafter. This is sometimes referred as "plug-and-play".

For this vision to become reality, supporting standards must be developed for the accompanying OAM&P systems, which will do the work for the operator with minimum manual intervention and oversight. The NGMN White Paper on Next Generation Mobile Networks puts it well in stating the overall goal as follows: "O&M systems should be an integral part of the network and not be designed and deployed as an afterthought".

Some of the important steps in activating a femto cell automatically include:

- Initial discovery by the femto cell of the operator's femto network gateway over the fixed broadband connection;

- Authentication and establishment of secure connection to the gateway based on the unique identity of the femto cell that is presented to the gateway;

- Automatic determination of the femto location, based either on GPS, and if in a local that does not have good GPS reception, with assistance from the surrounding macro network, and position location intelligence in the operator's core network;

- Automatic determination of the neighbor list, based on the measurements conducted by the femto cell when first installed; Likewise, being able to automatically cope with any macro cell network changes such as cell splits;

- Automatic determination and configuration of other radio parameters, such as band class and frequency of operation, transmit power, Pilot PN Offset, etc., without resorting to manual cell planning;

Once femto cell is in operation, its performance should be monitored automatically by the system and self-optimized in many of the aspects of operation. For example, the system can monitor hand-in and hand-out success rate. The aggregate (for all femto cells) success rate can be used to evaluate algorithms for radio self-configuration, and refine those algorithms, e.g. the algorithm for PN Offset planning.

Femto cell systems are the best application of SON, but OAM&P automation efforts should extend to macro cellular components of the network planning, management and maintenance, provisioning of network resources, subscriptions, and application management.

4.4.8 Cognitive Networks

Statistics show that there are inefficiencies in spectrum allocations and in the actual use of allocated spectrum. This is partly a result of variation of user densities, but also difficulties in managing more granular allocations. Spectrum licenses, by their nature, must be assigned for a relatively long period of time to make them economically viable for licensees. Yet technological changes are ever more rapid. Hence the appeal of cognitive radio networks, wherein communication systems "adapt" to and use available spectrum in a given locale, if not actually occupied by a licensee, or if in a license-free band.

Cognitive networks present a potential paradigm shift in spectrum managements. Regulatory agencies are adapting to a more flexible rules of use, by allowing secondary use, e.g. in unoccupied TV spectrum. The current licensed occupants have priority, but systems with cognitive network capabilities can use this spectrum otherwise. One potential use of cognitive networks is in peer-to-peer communication, and using relays, which allows ad-hoc networking to be established. The key technological capability is ability of communication devices to sense presence of available spectrum, which can be put to such use.

One of the side benefits of this technology is improved robustness in cases of widespread calamity, which is appealing to regulatory and government agencies, whose charters are to enable effective public assistance in such situations.

Cognitive networks could be one of the distinguishing areas of development opportunity for 3GPP2.

4.4.9 Machine-to-Machine Communication Applications

Cellular networks have the advantage of longer range and mobility support, which are lacking in other M2M standards.

Optimizing support for Machine-to-Machine (M2M) communications in 3GPP2 networks will allow operators to penetrate and establish a strong position in this emerging and potentially large market [3]. Enhancements to current cdma2000 1x and HRPD air-interface protocols for optimized M2M support will allow operators to leverage existing network deployments in the near term. This market spans a wide range of applications such as telematics, vending, POS applications, automation manufacturing and control, telemedicine, etc.

One of the advantages of the Femto system is that it can enable a new breed of M2M applications. These applications may be based on peer-to-peer communications that do not involve the macro network.

The desirable features to optimize support for M2M communications are outlined below, from both air-interface and network perspectives. These features and functionality to enhance support for M2M applications are suggested based on [3]. [4], and [5].

4.4.9.1 Subscription Management

The system should be able to support the following subscription management capabilities:

- Subscription management for a large number of terminals
- Activation of a large number of terminals simultaneously, as opposed to one at a time
- Assignment of terminals to a service provider without human intervention, in today's cellular network, activation is cumbersome process that involves in-store on by-phone contact followed by over-the-air (OTA) activation
- Ability for remote subscription change for a large number of devices in the field. For example, a chain of photo-copier stores (the photo-copiers have embedded cellular network connectivity) wishes to change their service provider. It should not be required that the device(s) be brought back to the service provider outlet
- Dynamic provisioning should be supported for M2M devices.

4.4.9.2 Security Management

The credentials of these M2M devices should be managed securely, including the following:

- Appropriate security mechanisms may include a combination of physical and network based methods
- The device should not be required to be placed in a physically secure location or even physically locked

Network-based challenge response mechanisms need to be explored. This may pose a significant challenge when coupled with other desirable features described later.

4.4.9.3 Charging and Accounting Management

Generation of charge records should be possible for a wide variety of applications that include bulk message transfers, high bit rate video monitoring from a few locations, communications from a very large number of very small payload sessions etc. Representative session frequencies and data payloads per session for a large number of M2M applications are indicated in Table 1:

Application	Examples	Access Frequency (sessions/unit time)	Number of Payload bytes/session
Vending	Initially for high value items such as phone cards, cigarettes for inventory management	<5 times/day	small (10s of bytes)
Machine monitoring/SCADA	Photocopiers, elevators, industrial machines, game machines where no access to local LAN for security reasons	<5 times/day	small
Automated meter reading	Electricity, gas meter reading	<5 times/day	small
Smart metering	Providing prices to end users for demand response, per appliance metering, parking meters etc	~ 50 times/day	small
Home security	As a backup to phone line or broadband	at least daily	small
Environmental Sensing	temperature, humidity, strain, road etc.	varied	small(if not aggregated), medium
Vehicle Tracking	Occassional need to locate vehicle (theft, lost in parking lot etc.)	rarely	small
Point of sale	gas stations, rental returns	~100 times/day	medium ((1000s to 10K byte)
Displays and Billboards	Traffic information on roads,dynamically changing advertisements, bus arrival times	1~100 times/day, ~1000 times/day	small to several mbytes
Remote Video Surveillance	Toll/speed cameras, remote entrances to buildings, oil pipe lines etc	continuous; rare if event triggered	Mbytes/sec
Fleet Management	car rental, taxis, trucks, staff scheduling	~10-100 times/day	small to Mbytes
Driver/Vehicle Performance Monitoring	Vehicle diagnostics(send back information on condition of car travel speed, etc)	~10-100 times/day	~1000 bytes
VehicleTraffic Information/Routin g/Navigation	Provide real-time traffic and routing	continuous	Bytes/sec
Telemedicine	Heart rate/ausculation rate	continuous when triggered	Kbytes/sec to Mbytes/sec

Table 1: Some M2M Applications and Their Requirements

In addition:

- Aggregate charging mechanisms that minimize network load and do not cause scaling problems with current network architectures should be considered
- Aggregate accounting across a number of devices should be supported

New roaming and mobility models for charging will be required. Alternate charging should be supported for stationary use. The stationary mode may need to be detected.

4.4.9.4 Network Management

M2M Network management should include direct device management (as opposed to user-mediated), activity detection and monitoring of devices to prevent fraudulent use. It may be necessary to provide device behavior information to the network for fraud detection and remedial action.

4.4.9.5 Address Management

Several challenges must be overcome to support deployment of large numbers of M2M devices and services are to be successfully deployed. These include:

- Mechanisms to overcome device ID (MEIDs, IMSIs) depletion
- Multiple subscriptions should be possible for a single M2M device each applied in its distinct subscription domain
- IP address management for static IP and dynamic IP assignment environments
- Group and per-operator addressing. It is expected that this will facilitate device management and subscription change and management

4.4.9.6 Data Management

Multiple communication paths should be supported for complete coverage. Different networks (cellular/WiFi) may be used at different times and data may come in from these different networks at different times. The system should be designed to have the ability to collate data from the same M2M device arriving through multiple interfaces.

4.4.9.7 New M2M Device Class

New terminal classes targeting M2M modules should be specified. M2M terminals need not have all of the functionalities of a full-fledged voice terminal. They can support fewer features such as reduced set of coding and modulation rates, hybrid ARQ modes, etc. For this reason, it is beneficial to have a separate class for such terminals with their own set of minimum requirements for testing.

4.4.9.8 Extended Battery and Low Power Operation

Battery life for M2M devices should be extended over current devices taking advantage of low power operation. A class of M2M applications, for example remote environmental sensing, is likely to be battery operated. Long battery life for such sensors is critical to the success of the application. Establishing the communication link with lower transmission powers will open up the cellular interface for a number of new applications, thereby increasing the number of devices using cellular networks. Operation at low powers is feasible because low data rate transmission is sufficient for many such applications.

Even when devices are not battery operated, limiting the transmit power can result in lower terminal complexity. Low power operation could reduce the filtering requirements since adjacent carrier interference will be reduced. It is beneficial to have a requirement for low power operation, e.g., to provide 95% coverage with 15 to 20 dB lower transmit power at a suitable transmission rate, which could be as low as 1 Kbps. Under low transmit power operating conditions, increased transmission range is not expected.

4.4.9.9 Extended Range Operation

Complementary to the low power requirement, extended range operation should be supported to take advantage of the low data rate. Since some of the M2M devices could be inside buildings it would be beneficial to extend the coverage for low data rates specifically meant for M2M communication.

4.4.9.10 Device Complexity Reduction

For low transmit power terminals, the possibility of relaxing the filtering requirements and still meeting the spectral mask/adjacent channel transmission power leakage limits should be investigated. Relaxed filtering requirements can potentially reduce the cost of the terminals.

Multi-code transmission increases the peak-to-average power ratio thus requiring a higher back-off and thereby limiting the range. Techniques to work around the need for multi-code transmissions should be investigated.

M2M applications generally do not require make before break seamless handoffs. This offers an opportunity to simplify the base band significantly by tracking only a single sector pilot at a given time. This can reduce pilot search requirements obviating the need for multiple searchers.

4.4.9.11 Scalability

Based on the low duty cycle, low throughput, and data transfer requirements of some of the applications, from an air-interface capacity point of view it would be possible to support a very large number of devices. However, it is necessary to ensure that other system aspects can handle a large number of devices that may be in the dormant state.

4.4.9.12 Peer-to-Peer Communication Applications

The objective of user-to-user communication applications (see illustration in Figure 4) is to enable heterogeneous devices (e.g., mobile phones, consumer electronic devices, PCs, etc.) to form overlay peer-to-peer networks to communicate with each other in a distributed fashion (see illustration in Figure 4). Networks are expected to help enable application deployment without significant costs other than the application development itself. They are also expected to drive addition of services without significant effect on infrastructure costs. An example use case is an extended personal network created using an affinity among devices.

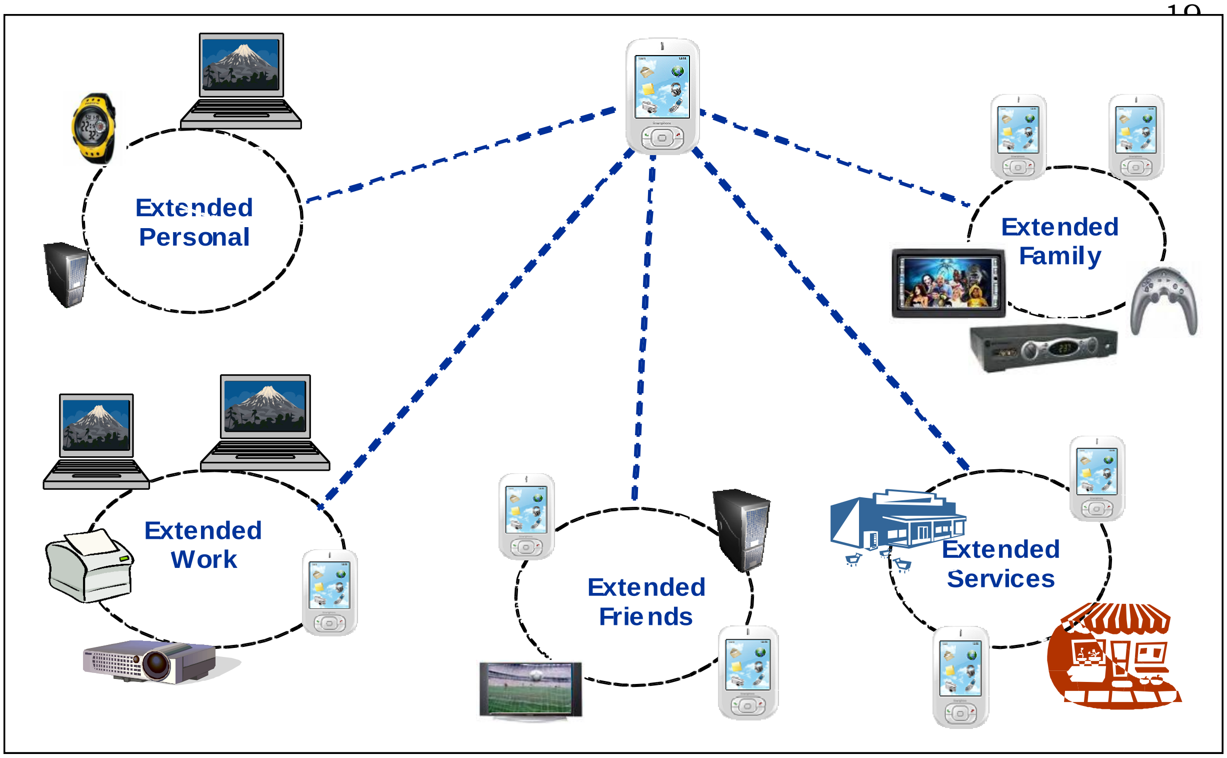

Figure 4: Peer-to-Peer Overlay Networks

This involves investigation and development of peer-to-peer network and service discovery, network formation and maintenance mechanisms and secure communications. This includes aspects such as Network Address Translation (NAT) and firewall traversal, service descriptions and discovery framework, and group communication. The idea is to develop common functionality to enable application development over peer-to-peer networks. A hybrid architecture composed of enrollment servers, accounting infrastructure and logging devices need to be part of the system.

4.4.10 Device Assisted Service Offerings (Cooperative Communications)

Cooperative communications occur between and among end-user Terminals (T) and the Network (N) where:

- Variants include N to T, N to N, and T to T
- Cooperative use of scarce resources such as battery, power, bandwidth, backhaul etc.
- Offer services through various combinations of Relays, MIMO, distributed antennas, etc.

5 Network and End-User Equipment Capabilities

5.1 Relays, Multi-hop

Wireless relays have existed as a concept for some time, but their commercial viability is improving as high data rate technologies and applications using them grow. The key benefits of wireless relays:

- Reduction in path loss, thus improving coverage (relay amplifies a signal before transmission)
- As a result of lower path loss, improved signal/noise ratio, allowing higher data rate transmission
- Less complex deployment

Relays can be used in certain situations to improve backhaul efficiency for operators, and they also enable a novel deployment model. In a newly deployed network, for example, relays can be put in place first, until traffic grows to warrant the full-fledges BS, which is more expensive than a relay. One can see that relays go hand-in-hand with femto cells. Relays enable more rapid deployment for coverage, until capacity growth occurs in an area.

Concept of relays is shown on Figure 5, which illustrates two basic variants of relay networks – Peer-to-peer AT Transmit/Receive, and Remote Relay Node.

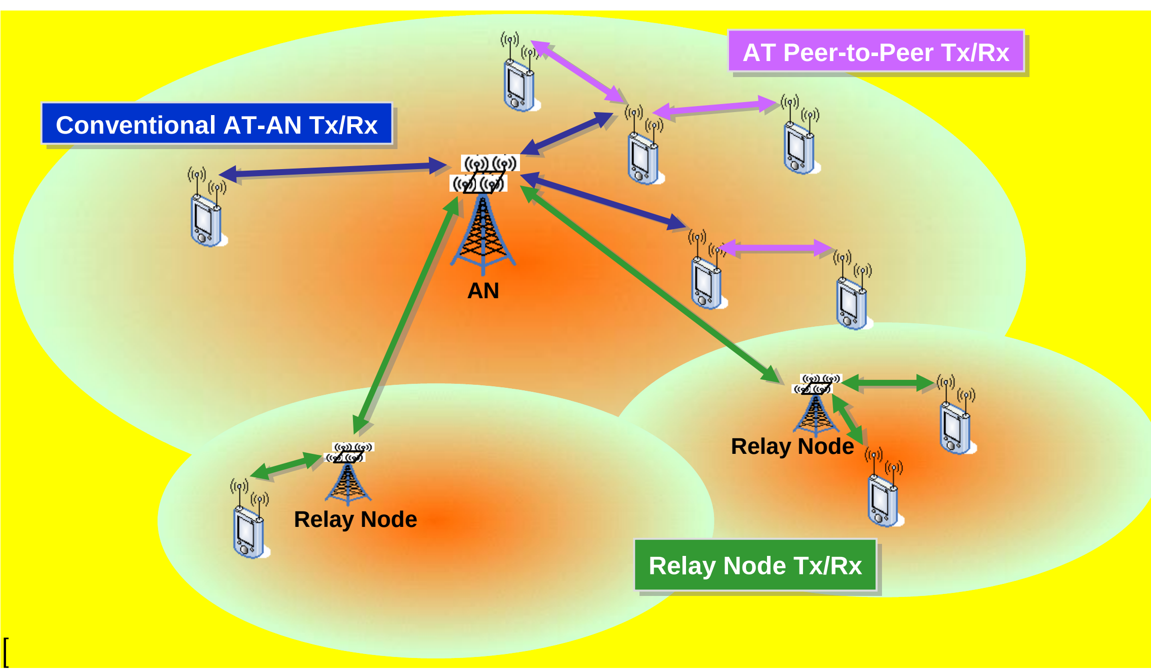

Figure 5: Illustration of Relays and Multi-hop Connections

Relays are not without drawbacks, and they have yet to be proven in an actual deployment scenario. The main drawbacks are complexity and increased signaling overhead. Multi-hop relays provide further potential benefits, but complexity is increased. However, solutions must include that option to allow migration from single to multi-hops.

In peer-to-peer relays, ATs cooperate by lending each other reception and transmission resources, i.e. an AT can act as a relay for another AT. In a multi-hop scenario, interference can be reduced, increasing overall efficiency, and likelihood of connectivity. This is particularly useful for emergency communication, under severe coverage conditions due to outages of traditional fixed infrastructure resources.

Mesh networking is closely related to relays. It's a concept of decentralizing network controls and scheduling. It's a way of taking multi-hop relays a step further. Relay and mesh networking can be helpful in certain situations, such as when there is clustering of mobiles (e.g. on a train).

5.2 Multimode System Selection

When system operators either own networks with non-cdma2000 air interfaces or have affiliates with non-cdma2000 air interface networks, multimode terminals will be required to allow the user to access service wherever it may be operating and on whatever compatible air interface is available. These multimode terminals will require a more flexible system selection mechanism to access those air interfaces based on geographic conditions and home operator priorities.

System selection is a reference to access management for a terminal that supports multiple radio access technologies. As multi-mode devices proliferate and technologies are intermingled, with co-existence of several varieties of 2G, 3G, and in the future 4G networks, WLANs, etc., this issue is gaining in prominence. 3GPP2 should cooperate with other standards bodies to develop standards support for comprehensive system selection that is technologically sound, and meets a variety of business interests of operators and needs of subscriber.

As a guiding principle, the end user and its device are in the best position to observe what technologies are available at a given locale, how user experience shapes selection, etc. This should be done with the oversight and consent of the operator.

Any operator policy constraints should be pushed to the terminal, so that the terminal and user can, given those constraints, make the selection in a way that is user friendly, largely automatic, and preferably based on customary usage model of a given user, which however is flexible to allow migration of such usage model. The solution should have the flexibility to address various business and situational cases. Low power consumption and minimal time to acquire service are major requirements for a multimode system selection mechanism.

5.3 Terminal Battery and Power Consumption Improvements

New device technologies or services may cause increases in terminal power consumption. Lowering power consumption and extending battery life are required to maximize the user experience.

In addition to battery life considerations for user terminals, power consumption by infrastructure functional elements should also be of concern in the current era of worldwide attention given to global warming and the drive toward cleaner and more efficient products and technologies. 3GPP2 should do its part to address these issues by developing and refining standards such that they are conducive to green technologies in broader sense. The following examples are meant to illustrate some potential efforts.

- Wireless traffic volumes go down at night, when users are less active. Base stations supporting multiple carrier frequencies could potentially handle the lower night-time traffic with fewer carriers, by moving users to a reduced set of carriers and temporarily turning off transmission of unused ones.

- With the deployment of femto cells, their owners will have an incentive to turn them off when not in use, in order to save power (e.g. while members of the household are all at work or in school during the day, or at night). Equally significantly, the macro system will benefit from reduced interference by elimination of radio transmission from unused femto base stations. It is feasible to standardize a system with mobile assisted power on/off control of femto cells, which will make this process seamless, not requiring any conscious action by users. A mobile can automatically generate commands transmitted over the macro cellular system, based on the mobile's proximity to its home femto cell. A command signifying mobile's entrance into its home zone can be used to turn the femto cell on. In the converse case, mobile's departure away from its home zone can be used to turn the femto cell off. Mobile's location need not be precise, e.g. such operation should not require GPS precision, or any close tracking of mobile's location, which could be too costly in terms of mobile's own power consumption. Such a system will have to have an override capability, allowing the operator to keep femto cells on, for the purpose of responding to a general emergency, e.g. in the case of natural disaster. Under those circumstances, the added capacity and robustness of the femto system becomes priority. Similarly, if an open access femto is serving a mobile who is not the owner of the femto cell, the feature should be temporarily disabled, or it should take effect upon first moving the user to the macro cellular system.

5.4 Inter-Technology Interworking

At present, the wireless industry is characterized by the following developments, driven by trends discussed in the beginning of this document.

- Proliferation of multimode devices
- On-going technology migration
- Imperative for global interoperability, as wireless operators operate internationally and strive to support roaming in a comprehensive fashion

3GPP2 should be committed to supporting inter-technology interworking. This allows operators to be more flexible in their migration plans, to introduce innovative solutions gradually and without risk of negative impact on existing subscribers. As stated in the opening parts of this Vision Document, the industry is firmly on the path of global cooperation on technological front, as well as on the business front.

Technology interworking has multiple facets including:

- Multi-mode system selection (see Section 5.6)
- Roaming and network support for multi-mode terminals
- Network and subscription policy issues
- Security

Interworking culminates in mobility from one access technology to another, with each technology possibly being defined by a different standards organization. Inter-organizational standards cooperation is critical. 3GPP2 has a strong track record of addressing inter-technology issues in a prudent fashion, and should continue a sustained effort in the same vane.

3GPP2 is developing inter-working solutions between 3GPP2 technologies (HRPD and 1x) and 3GPP LTE and WiMAX®.

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The eHRPD network is an extension of the HRPD access network which enables single-radio and multi-radio terminals to attach to the EPC (evolved packet core) of 3GPP. Additionally, eHRPD support seamless handoffs between E-UTRAN and HRPD with single-radio terminals. Voice call continuity with and fallback to cdma2000 1x for voice service is also supported.

The interworking of HRPD with WiMAX enables seamless handoffs between WiMAX and HRPD systems for single-radio terminals. A dual-radio interworking solution between HRPD and WiMAX has also been developed by the WiMAX Forum®.

It can thus be seen that 3GPP2 has a strong track record of addressing inter-technology issues in a prudent fashion, and should continue a sustained effort in the same vane.

6 CANDIDATE RADIO TECHNOLOGIES

It is imperative for cdma2000 family operators to maintain technology competitiveness of cdma2000-1x and HRPD. cdma2000 family is the best and most economical proven platform for voice and packet data communication.

3GPP2 should continue to update band classes and sub-classes, so as to broaden the market reach of cdma2000.

In addition to aggressive and industry-distinguishing performance improvements in 1x and HRPD, 3GPP2 should explore additional technical areas of leadership in wireless industry, possibly cognitive radio.

6.1 Capacity Improvements

Further VoIP and CS voice capacity enhancements, i.e. further spectrum efficiency improvements, are universally shared and enduring goals for 3GPP2. VoIP-ready HRPD systems are expected to lead the market in wireless deployments.

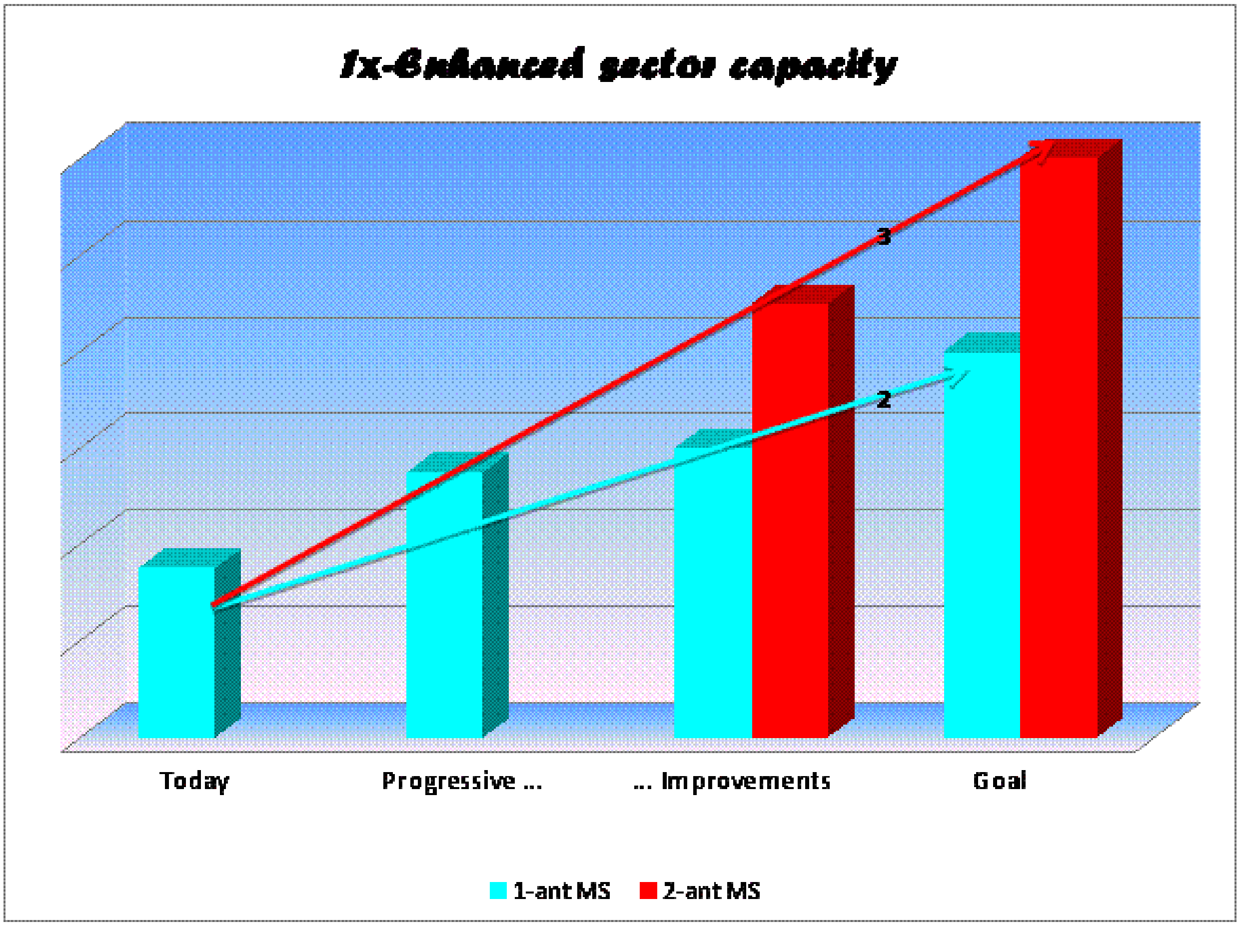

Figure 6: Capacity Improvement Goals of 1x-Enhanced

Note: Capacity estimates are based on a combination of simulations and analysis of proposed changes performed by Qualcomm. Performance figures are provided to illustrate goals, and subject to change.

Techniques to be considered for this improved capacity include but are not limited to:

- Interference Cancellation for Forward and Reverse Link (FLIC and RLIC)
- Hybrid Automatic Repeat request (HARQ)
- Power Control Optimization
- Smart Blanking

The following must also be considered:

- Note that operators may choose to deploy in increments, or to leap-frog any intermediate steps, some of which are independent of each other (e.g., FLIC is a mobile feature, RLIC is a base station feature, and are independent from one another).

- Lower rate and rate controls on EVRC can be used to deal with capacity at times of peak traffic, but care should be taken that voice quality not be compromised, so as not to adversely affect customer satisfaction.

- With these capacity improvement measures, cdma2000 1x-Enhanced should be considerably ahead in voice spectral efficiency in comparison to foreseeable advancements in competing technologies.

- Regarding HRPD-Enhanced, support of heterogeneous networks (pico cells and femto cells) will enhance the performance and allow deployment flexibility.

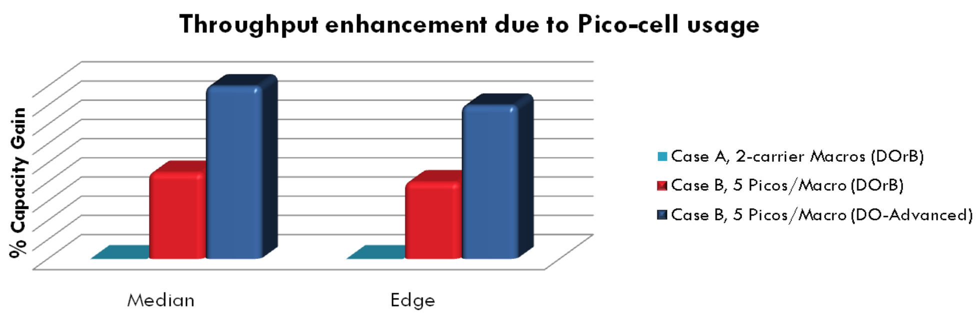

Figure 7: Illustration of HRPD-Enhanced Capacity Improvements

(Source: QUALCOMM)

Figure 7 illustrates performance gains achievable by heterogeneous network deployments and other advancements being studied for HRPD-Enhanced. The figure illustrates two deployment options on top of an already deployed macro carrier:

Case A: 2nd macro carrier deployed in all cell-sites

Case B: Deploying dual-carrier pico-cells wherever needed

Comparative performance of HRPD Revision B and HRPD-Enhanced is shown for Case B.

This serves to illustrate deployment flexibility and the overall advantage that a narrower band system can have with heterogeneous networks, when hot-spot coverage is required.

- Reduced transmission latency is an important performance characteristic for real-world applications, such as http. In HRPD-Enhanced, radio interface component of the round-trip packet delay can be improved with load adaptive reverse link latency target methodology.

- Simultaneous circuit-switched voice over cdma2000 1x and packet-switched data over HRPD is feasible using a multi-carrier capable terminal. Modern chips contain a fast A/D converter (around 100 MHz and soon higher) and other RF, analog, and DSP components enabling these broadband capable terminals. When a cdma2000 1x and an HRPD carrier are within terminal bandwidth capability, both can be received simultaneously. On the transmit side, the two signals can be combined. This is independent of the HRPD radio interface revision. This is illustrated in Figure 8, which shows possible options in combining 2 or 3 multi-carriers with spacing of up to 6 carriers total.

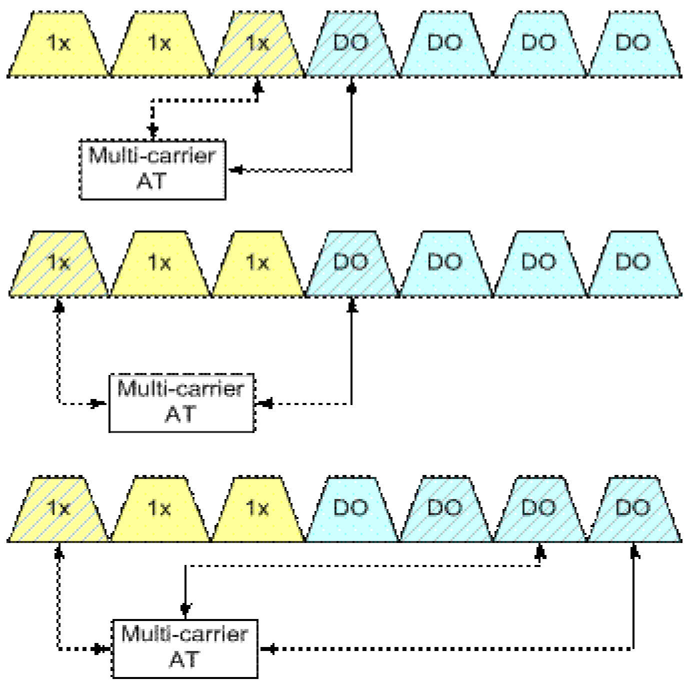

Figure 8: Combined cdma2000-1x and HRPD Multicarrier Placement

Each cdma2000 1x and HRPD can operate independently, e.g., an application on one can start independently of what is happening with another. Specifications need to be developed regarding handling MS capability limitations (e.g. allowed carrier separation, relative priority between voice on cdma2000-1X and data on HRPD, etc.)

Simultaneous cdma2000 1x and HRPD entails multiple simultaneous Tx/Rx processes (bandwidth aggregation).

6.2 Femto Cell Support

The advent of femto cells is an artifact of one of the significant trends in the telecommunication industry known as fixed-mobile convergence (FMC), which encompasses multiple radio technologies including cdma2000 1x, HRPD, GSM, WCDMA/HSDPA, WLAN, etc. Both cdma2000 1x and HRPD are well positioned in this trend, and the goal of 3GPP2 should be to maintain and advance that position with successful evolution of femto cell systems for these technologies. Femto cells deployed in the licensed spectrum with smooth interworking and integration with the macro cellular system is the truest kind of FMC, since allows existing mobile devices to instantly attain FMC capability.

There are favorable drivers for femto cell growth including:

- Improvements in wireless coverage for weak or dead spots in the macro network or for areas outside the macro network coverage area
- Coverage improvements to resolve in-building penetration problems
- cdma2000 1x and HRPD "hot spot" coverage areas
- Coverage improvements to achieve higher data rates than may be achievable in light of lower SINR conditions, multipath, and other fading problems in the macro network
- Increased customer loyalty
- Economical deployment vis-à-vis macro cell deployment and operation complexities

Femto cells can significantly contribute to the overall network growth in a friendly and economical fashion. Femto cells can also become home network platforms and media hubs.

The initial focus of 3GPP2 specification activities for femto cell support is being driven as a phased effort as defined in S.R0126-0 v1.0 System Requirements for Femto Cell Systems as follows:

> "Phase 1: Development of basic femto cell functionality intended for residential use, for support of legacy mobiles and limited femto-macro mobility when both macro and femto operate the same radio interface (e.g., both are cdma2000-1x).
>
> Phase 2: Enhancements for more comprehensive mobility, including femto-femto handoffs, mobility between dissimilar radio interfaces, etc.

Phase 2 may additionally include enhancements that can facilitate denser femto cell deployments."

Phase 1 primarily focused on supporting a CLOSED access system – that is a system where access to the femto cell is limited to a fixed number of subscribers who have been specifically authorized to use that system. A closed access system will provide the basic platform for a residential or SOHO network intended to achieve the following objectives:

- Provide improved coverage for weak or dead spots in the macro network or for areas outside the macro network coverage area
- Provide improved coverage to resolve in-building penetration problems
- Provide improved coverage to achieve higher data rates than may be achievable in light of lower SINR conditions, multipath, and other fading problems in the macro network

However, the potential benefits to an operator's network cannot be achieved until OPEN access femto cells are supported. The target benefits include full integration into the macro network to support load balancing, interference mitigation, and network controlled capacity management strategies.

The key technical issues that should be addressed for support of open access femto cell systems include:

- Full femto-macro mobility including femto hand in and femto hand out
- Fell femto-femto mobility for areas that need to be covered by multiple femto cell access points
- Enhanced femto-macro and femto-femto interference cancellation support including both band splitting and shared frequency deployments. These strategies are required to support denser femto cell deployments. These interference cancellation schemes my include, but are not limited to, the following:
    - Directional antennas
    - MIMO/beamforming femto cell access points
    - Frequency and time hopping algorithms
    - Adaptive power control algorithms

- Hysteresis algorithms to prevent femto-macro and femto-femto "ping pong" accesses

- Algorithms to reserve femto bandwidth for primary users (e.g., users who are logged into the femto cell access point vs. those users redirected for improved network performance)

Critical for femto cell systems success will be ease of installation at customer premises, without extensive hands-on support by operator. This plug-and-play and no-touch aspects of OAM&P for femto cells is broadly known as Self-Organizing Networks (SON), and is discussed at some detail in Section 4.10. Femto cell systems are ideal candidates for proving out SON concepts. SON aspects of femto cells are key to their success, and will be subject of standardization in the upcoming period.

Generally speaking, open access to femto cells is the current direction of the market. This does not seem likely to change in the next 3-5 years. This should be the ongoing assumption in 3GPP2. Open access removes much uncertainty concerning interference, which is the most critical issue with femto cells, especially for legacy mobiles. At the same time, it is critical to specify robust handoff procedures from femto to macro system, to cope with situations such as exhaustion of femto channel resources.

Enterprise access may be the next wave of interest for femto cells, allowing deployment of a grid of femto cells in close proximity of each other, intended to provide carpet coverage within an enterprise campus. Business motivation for such deployments is similar to WLAN access, but could be amplified due to voice services capability. For this application, inter-femto handoffs should be fully standardized.

In conjunction with the enterprise applications, 3GPP2 should also explore the possibility of inter-femto soft handoff, and in the longer run, macro-femto soft handoff. At present, macro-femto handoffs are not studied extensively due to the fact that considerably tighter integration of the macro system and femto system would be necessary.

To prove out the femto business case, operators are initially reluctant to make major changes to the macro system in order to support the nascent femto market. However, this situation will change as femto cells get proven out in the market place, and as their advantages in capacity growth upkeep become more apparent.

Current market interest for femto cells is primarily focused on cdma2000 1x. Over time, addition of HRPD capability will occur. Eventually, HRPD-only femto cells may become popular for PC access, but in the longer term also for VoIP. 3GPP2 should anticipate such developments and be ready with standards, so that products may address market demand in a timely fashion, once it materializes.

In conjunction with that, native use of IMS signaling from HRPD femto cells has the potential to substantially simplify the femto system architecture. This would facilitate support of VoIP and packet-switched video telephony using femto cells, and may stimulate the market for video communication. The economy for PSVT is more appealing than on the macro system, also from the man-machine interface perspective, video is more realistic from fixed or semi-fixed location.

One interesting potential application of femto and pico cells is venue-casts - BCMCS application over a temporarily deployed set of femto cells or pico cells in a conference or sports event venue. In addition to venue-casting, such deployment may be used by operator as a tool to relieve traffic from the macro system in a locale with a large concentration of users.

Another application that is similar in nature is AdHoc femtos, small personal or small group networks. Starting with emergency applications as market motivator, this application of femtos can grow into commercial realm, such as student groups at school.

On the technology front, advance MIMO antenna configuration can be attractive to enable higher data rates on HRPD femtos. This will allow HRPD femtos to fare favorably against competing technologies.

An additional technological opportunity is interference cancellation (IC) at femto receivers, which may prove important in dense deployments of femtos, such as the ones in enterprise locations. Using signaling capabilities required for handoffs, IC can improve spectrum efficiency performance, and can be an additional tool in interference management, critical for the long terms success of femto systems.

Further potential for integration exists in inclusion of fixed broadband modems into the femto cell. Though this is not subject to standardization, 3GPP2 should ensure that standards specifications allow such product developments.

On the handset side, enhancements for femto-aware mobiles are already taking shape in 3GPP2, with system selection using advanced concept known as PUZL (Preferred User Zone Location), which individually in each mobile device contains a database of descriptors and pointers to femto cells for that device, allowing it to find them with minimum search effort. Further advancements using PUZL concept should be pursued, allowing autonomous configuration system selection for femto-aware mobiles, with good battery performance and taking maximum advantage of the deployed femto cell system.

To reduce MS complexity for mobility between dissimilar radio interfaces (FDD/TDD, cdma2000/non-cdma2000 air interfaces, etc.) the capability should be specified so that the MS is not required to transmit simultaneously on both radio interfaces (i.e., specifications for single radio devices design should be supported).

7 Services and Applications Roadmap

This section provides a roadmap with service development time-lines. Figure 9 provides a high level roadmap for various applications and services previously described in this document. Temporal dependencies and interactions between some services may exist due to some common enabling functions and building blocks. These temporal and feature interactions are not captured in this time-line primarily to keep the figure simple and provide a high level view.

In Figure 9, the start of the arrow depicts either on-going efforts at the time of this document being written or the view of anticipated activities in the coming years. The arrow end-points only reflect anticipated completion of some simple ideas currently being discussed in 3GPP2. As research in many of these complex technology areas are currently underway, we anticipate new ideas will emerge leading to continuing enhancements. Only broad categories are highlighted. Many of these categories may be broken down into several components, if desired.

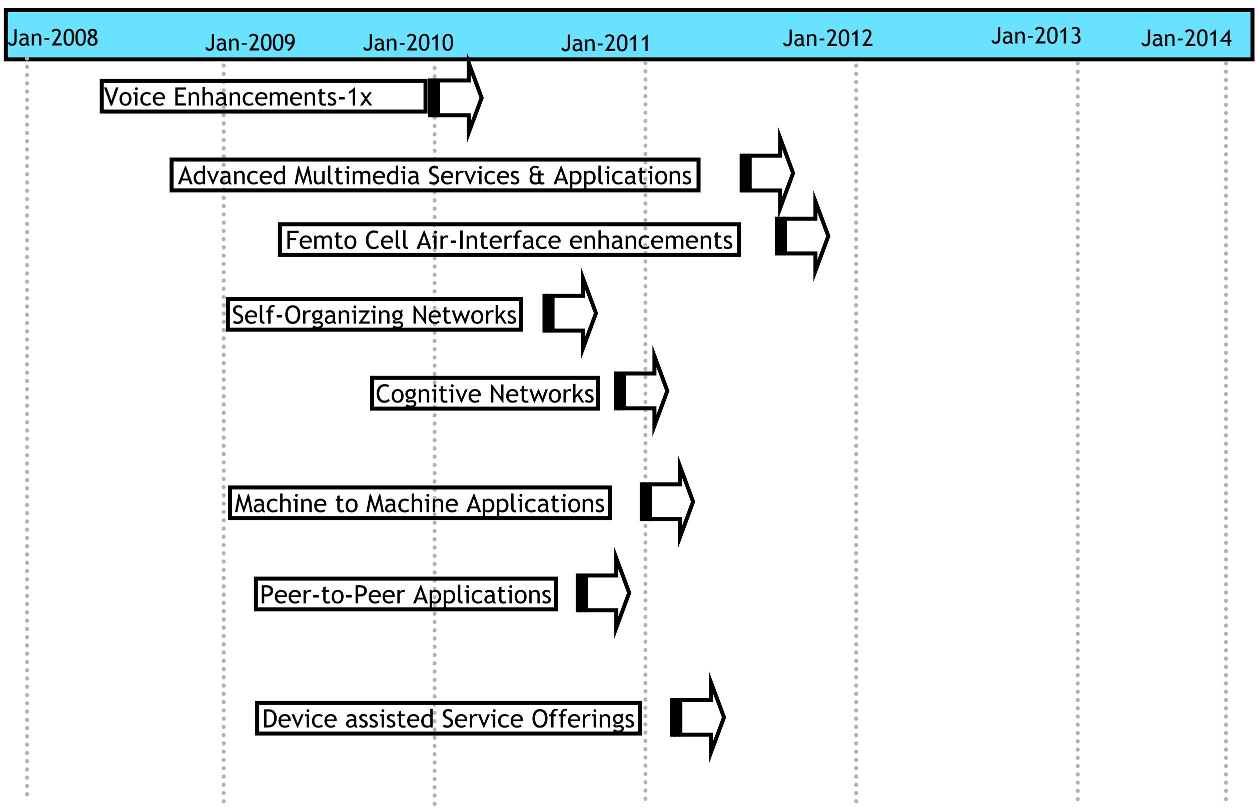

Figure 9: Services and Applications Time-line (Anticipated)

Annex 1 – Operator Priorities for cdma2000 1x and HRPD Enhancements

<u>HRPD Enhancements</u>

Interworking with Non-3GPP2 Systems

- Link Layer Interworking
- Network Layer Interworking

Enhanced Capacity

- Interference Cancellation Forward Link
- Interference Cancellation Reverse Link
- Multiple Antennas (MIMO, SDMA, OSTMA, etc.)

- Femto Cell Interference Management

<u>cmda2000 1x Enhancements</u>

Interworking with Non-3GPP2 Systems

- Link Layer Interworking
- Network Layer Interworking

Air Interface Modifications for Femto

Enhanced Voice Capacity

- New Radio Configuration (Eight rate blanking, slower power control, early decoding of frames)
- Quasi-Orthogonal Functions
- Power Control Changes (ZTE, Qualcomm or Motorola method)
- Forward Link Interference Cancellation (Qualcomm Linear Interference Cancellation)
- Reverse Link Interference Cancellation

<u>Other Related Enhancements</u>

MIMO on 1x and HRPD

Enhancements in Throughput on 1x and HRPD Using the Same Spectrum Bandwidth

Co-existence of Multiple Vendors in the Same Area/Business District

Simultaneous 1x and HPRD

Seamless 1x/HRPD Integration