INTERWORKING VS. STANDARDIZATION OF WIRELESS NETWORKS

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ABSTRACT
The wireless access networks are very diverse. While standardization is more appropriate for systems serving similar purposes, different standards may continue to serve different needs. It is impractical trying to arrive at one single one-size-fit-all global standard of wireless system in the foreseeable future. Instead, interworking technologies are needed to complement the standardization efforts.

For example, the IEEE 802.11 family of WirelessLAN (WLAN) and the Wireless Data Public Land Mobile Network (PLMN) have different capabilities in distance range, data rate, and in other features, and may complement each other. Combining WLAN and PLMN Wireless data through interworking will enable these LAN and WAN technologies to complement each other to enhance the available wireless network services. Interworking technology is defined here as the enabling technologies such that any customer of any service provider may run any communication application on any wireless communication device to communicate with any other customers.

Keywords – Information technology, Interworking, standards, Wireless network.

1. INTRODUCTION
The wireless systems and standards are very diverse. There had been numerous attempts to converge the wireless telecom systems into one single global standard. From the experience of 3G Wireless standardization, there are also needs for the same core network to accommodate different existing systems. Especially for the radio access networks, different radio access standards continue to exist in different countries for different purposes. It then became a major challenge to arrive at a converged core network to serve different types of wireless access networks.

The 3GPP and 3GPP2 programs are respectively providing evolution paths for existing GSM and IS-95 CDMA families of cellular networks. Meanwhile, the number of different wireless telecom access systems is not diminishing. In addition, the wireless standards in the IEEE 802 family continue to grow in number and in the extent they are being used.

The 4G Wireless is also trying to converge different core networks for both wireless and wireless technologies. Yet the wireless access networks may continue to be diverse.

From the technologies point of view, different wireless technology systems do serve better in different environments. From the customer point of view, the usage of wireless services should be integrated into one integrated service offer. While the core network may converge to a single standard, the different access network systems need to seamlessly interwork.

Major standardization efforts have been going on everywhere, and prior work on interworking include [1-5].

The view in this paper is while standardization is more appropriate for systems serving similar purposes, different standards may continue to serve different needs. It is therefore not just beneficial to interwork, but it is an essential strategy to develop interworking technologies to complement the standardization efforts.

2. DIFFERENT WIRELESS ACCESS NETWORKS
There is the proliferation of numerous different wireless standards. We first list some of them.

One group of wireless systems are the public land mobile networks (PLMN) used primarily by the cellular telecom service providers and are
shown in Figure 1. What are common in these PLMN systems is that each cell can be at least several km in radius. With handover between these cells, the distance range of service falls into that of the wide area network (WAN).

At still longer distance ranges but not belonging to the PLMN family are the broadcast network including DAB and DVB-T covering large geographical regions and the satellite network with coverage at the global level.

The PLMN systems includes the existing GSM and IS-95 CDMA in 2G Wireless, which evolves respectively to GPRS and 1XCDMA to provide data service in 2.5G Wireless, and then evolves respectively to UMTS and CDMA2000 (or 3XCDMA) in 3G Wireless. The supposedly high data rate of 2Mbps of shared capacity back in year 2000 in the IMT2000 3G Wireless requirements is not high compared with a host of broadband access technologies such as DSL, cable, and fiber in the fixed access networks. In order that wireless systems can replace the wireline counterpart, the data rate for 4G will be in the range of 50-200Mbps. Yet increase in data rate is not the only primary issue. The complexity and the huge amount of functions in 3G systems are partly responsible for the high cost, which is an important obstacle for wider use of 3G Wireless systems. 4G systems will need to be at much lower cost to be competitive.

Different wireless access network systems have good technological reasons to exist. There are different power requirements, different distance ranges, different data rates, and different carrier frequencies. Different systems are therefore needed to optimize the performance and cost for different requirements. The most common ones are the group of wireless systems in the IEEE 802 family of standards, shown in Figure 2.

At the personal area network (PAN) distance ranges within 1 meter is the 802.15 Bluetooth standard. At the local area network (LAN) distance ranges within 100 m are the 802.11 a/b/g WirelessLAN standards with shared data rates of 11 and 54 Mbps. At the metropolitan area network (MAN) distance ranges within 3-8km is also the 802.20 WiMobile standard to provide 1Mbps data rate per user. At WAN distance ranges within 30-50km are the 802.16 family of WiMAX standards providing shared data rates of up to 70Mbps.

The different wireless systems provide the said data rates to serve up to the said distance range. They are low cost systems providing the bare data transfer. Each standard is followed by very many devices sharing the same set of user environment. Low cost is then possible with high volume production.

The proliferation of many different wireless systems may show that such a diverse number of wireless standards are indeed necessary. For example, WirelessLAN can provide relatively higher data rate but may only do so economically in a smaller geographical area of a hotspot. On the other hand, 2.5G or 3G network has a much larger coverage area but with relatively smaller
data rate. For the future 4G Wireless, it could be impractical to attain the same low cost with a one-size-fit-all solution. We can still share the same core network through a multiservice platform. Yet the different wireless access networks need to interwork seamlessly. We will explain what we mean by seamless interworking in the next section.

3. SERVICE REQUIREMENTS OF INTERWORKING

While it may be for technological and cost reasons that different wireless standards will better serve in different requirements, the customer should only need to care about the service and not to have to care about different technologies. In addition, the customers should not have to subscribe separately to these different wireless technologies and to keep track of these different accounts.

We may define the desired service without referencing to the different wireless technologies first. We first recall that a well known motto used as an objective for some telecom service provider in the 1980’s and 1990’s was the following 4 any’s: anyone can communicate anywhere at anytime in any format. This is a clear motto in non-technical language. The communication systems today have actually achieved this already today. The only catch is that one can indeed use a system to communicate with someone else but only with those who are using a compatible system and sometimes even subscribing to the same service. The questions are therefore which application, what system, which network, etc. is one using.

It is therefore desirable to add the following service requirements, which also consist of 4 any’s: Any customer (subscribing to any one wireless service provider) may run any (communication) application using any device connected to any network to communicate with any other customer who is subscribing to any other service provider and who is also using any other device in any other network.

4. INTERWORKING WLAN AND 3G WIRELESS

Interworking involves technologies and therefore costs. Interworking is therefore not necessarily mandatory among all the different wireless access networks. There need to be benefits to interworking. The following examines the benefits of interworking WLAN and 3G Wireless, which are different network technologies to provide wireless access. We first compare their capabilities.

Wireless local area networks (WLANs) use traditional LAN technology with a wireless interface. WLANs provide relatively high-speed data communication in small areas such as a building or an office. The wireless connection allows users to move around in a confined area while they are still connected to the networks. With the introduction of small portable devices such as personal digital assistants (PDAs), the laptop computer with either built-in WLAN support or PCMCIA wireless LAN adapter, the WLAN technology has begun to grow rapidly in usage since 2001.

The 3G Wireless are a family of wide area wireless network standards qualified according to International Mobile Telecommunication IMT2000 requirements. 3G Wireless supports not only the voice services of 2G wireless telephone networks but also many more services of higher speed wireless packet data networks. These services possess the capability of transporting multimedia, always on, and charging not according to connection time.

The 3G Wireless networks are wide area networks (WAN) whereas WirelessLAN are local area networks (LAN) with ranges of the order of 100 meters.

The maximum data rate for 3G Wireless is 384kbps to 2Mbps depending on the speed of mobility of the user. WLAN has a higher shared data rate of 11 Mbps – 54 Mbps.

The 3G Wireless networks use licensed spectrum which is responsible for higher cost. 3G Wireless services are regulated and require expensive investment from the service provider but are reliable. WLAN uses unlicensed spectrum, so that the cost of usage is lower. WLAN are largely unregulated enabling a lower
start-up investment from the service provider.

3G Wireless networks tend to cover much larger cells with mixed density of users inside, whereas The WLANs tend to be pockets of smaller regions of LANs where the customers are dense enough. It becomes difficult for WLAN users to roam from one WLAN in one building to another WLAN in a different building because there will likely be no access points in the open space between the buildings.

5. TECHNOLOGICAL FOR INTERWORKING [5]

The technical requirements of Interworking are defined in the following. We have included the summary of some well known but closely related technologies in order to draw the distinctions between them and to clarify their relationship to interworking.

5.1 Internetworking

The different networks need to be connected to each other. The technology is that of internetworking in terms of interfacing at different network protocol layers. Requirements to interfacing different networks may be expressed With the 5-layered network protocol (physical, data link, network, transport, application) model, applications from 2 different networks may exchange messages at common protocol layer such as the IP layer in a common form, regardless of the differences of layers below this protocol layer in each network. While such exchanges of messages between the 2 networks are essential, they are not sufficient to meet the interwork requirements defined in the previous Section.

Although a standard protocol may be used to interface between different systems, different applications in remote locations also need to be interoperable.

5.2 Interoperability

Remote users may be using running their applications on different operating systems, such as Linux, MS windows, or Macintosh. These operating systems may also be running on top of different platforms, which may in turn be running on top of the different networks. Each of these platforms needs to have the appropriate application program interface. The applications are using higher level computer languages but the application program interface takes care of the translation for different platforms.

5.3 Technological implications for the customer requirements

We now come back to the definition of interworking in terms of service to the customer and to examine what technologies need to be applied to them.

We first elaborate the requirements into different cases. In the following, customer A refers to a customer of a service provider in network A. A device A is a device supported by the service provider in network A. An application A is an application originally supported by the service provider in network A running on device A. Customer B, device B and application B in network B have similar meaning. A general mobility requirement can be stated as follows:

Customer A may run an application A or B, using device A or B, in network A or B to communicate with applications in other wireless systems in the same network or a different network.

This is a very comprehensive requirement, which we can subdivide into different mobility requirements.

1) A-A-A-A Case: Customer A may run an application A using a device A in network A to communicate with applications in other wireless systems in the same or different network. This involves internetworking and interoperability requirements.

2) B-A-A-A Case: Customer B may run an application A using a device A in network A to communicate with applications in other wireless systems in the same or different network. This involves personal mobility and security in addition to the requirements in 1).

3) B-B-A-A Case: Customer B may run an application B using a device A in network A to communicate with applications in other wireless systems in the same or different network. This involves service mobility in addition to the requirements in 2).

4) B-B-B-A Case: Customer B may run an application B using a device B in network A to communicate with applications in other wireless systems in the same or different network.
communicate with applications in other wireless systems in the same or different network. This involves terminal mobility in addition to the requirements in 3).

A systematic way to organize these requirements is given in Table I.

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>DIFFERENT CASES OF INTERWORKING.</th>
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<tr>
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<td>1</td>
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<tr>
<td>Customer</td>
<td>A</td>
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<tr>
<td>Application</td>
<td>A</td>
</tr>
<tr>
<td>Device</td>
<td>A</td>
</tr>
<tr>
<td>Network</td>
<td>A</td>
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</table>

In 1), the interoperability requirements between different networks include the ability to tailor the application according to the services available. An example is that a Toll grade voice application may be communicating to hi-fi grade sound application in a network with broader bandwidth not available to the network with the Toll grade voice application. If real-time communication is needed, the hi-fi grade sound may be downgraded to Toll grade voice.

Another example is to run a client application from the slower bandwidth network with a server application from a broader bandwidth network. For example, a system A application may support streaming at a lower resolution because of lower bandwidth, whereas a system B application may support streaming at a higher resolution with a higher bandwidth. It is certainly possible to downgrade the content from a higher resolution to lower resolution. Yet when transmission delays are not of concern, an alternative to stream a hi-fi sound or a higher resolution picture from the server is to buffer the high bandwidth data before playing back to the customer.

In addition, the set of QoS requirements from the originating network needs to be honored in any transit networks and in the destination network. The parameters for some QoS may not match exactly between different networks. They may then be honored across different networks by picking parameters with the closest match to the meaning of the QoS in the previous network.

In 2), the system needs to handle personal mobility and security. Personal mobility in general enables customer B to use the same address in different devices. It requires the network to know that customer B who was previously associated with a certain device is now using a different device, so that the data destined to customer B need to be redirected to the address of the other device that B is now associated with. In this case however, the new device belongs to a different network A. Therefore customer B needs to be authenticated in network system A whereas the secured customer data were stored in network system B. An example of handling such a security problem between WLAN and the CDMA2000 network was discussed in [2-3].

In 3), part of the additional requirements is described as service mobility. The implication of service mobility usually deals with configuration in that the user is presented with the same set of services from all end-points.

For interworking between different network systems, a more general requirement stated here is that the customer B who is now using device A in network A is also able to use an application B supported in network B but may be usually not available in network A. For example, assume that customer B is used to making phone calls using one’s home network B. Now customer B is inside a building with WLAN. Customer B is now using a computer with WLAN connection, and is trying to make a phone call or to receive a phone call with that computer. As of year 2004, making a phone call with a computer is sophisticated if not difficult. Although some software does enable exchange of voice messages, the quality is at times not yet comparable to that of a phone line.

With the business motivations stated above for interworking, we anticipate that making a phone call this way should give the customer the same service and the process will be as user friendly as making a phone call with a cellular phone. The requirement stated here may call for different implementations. One implementation would be that the device A be equipped with all the capabilities and services as device B, if possible. Yet there is still the possibility that the application B is usually not supported in network system provider A for reasons such as licensing etc. In this case, a possible implementation is to automatically download a use-once-only software version of the original application through its
broadband network. The program is likely to be an embedded program so that it can execute on its own. The program is also likely to be restricted to use once only during the session of this application by customer B and may automatically be removed after the session so that copyright is not violated.

In 4), the additional requirements involve terminal mobility, which was defined to allow users to move from one location to another while having the same set of services available.

Personal mobility involves additional roaming and handover (or handoff) technologies, which may be subdivided into the following:

4-1) Customers of network B may request the service (turn on equipment) from the new network A and was not connected to network A or B prior to that.

4-2) Customers of network B may request the service from the new network A while the equipment has already been turned on from network B but the requested application was not running.

4-3) Customers of network B may request the service from the new network A while the equipment has already been turned on and the requested application also has already been running using network B. In order words, the application is seamlessly handed off from network B to network A.

These three handover cases are organized in Table II.

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<th>4-1</th>
<th>4-2</th>
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<tbody>
<tr>
<td>Device has already been connected to prior network?</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Application has already been running?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

In all these cases, there are technologies for security and for charging.

As the customer logs into another network (roaming), the customer needs to be authenticated in the new network using the data from the home network.

For charging, the new network needs to be able to charge the service. The charge could be through the home network provider or could be for exchange of complementary service between the service providers to support their customers to roam to each other’s network. The charging policy may differ depending on the service agreements among these providers.

In (4-2), a customer may or may not be required to log in again, depending on the service subscription agreement, the type of service, and customer preferences possibly stored in a customer configuration file in the home network.

For example, customer using device connected to WLAN may move to another location outside the range of WLAN but covered by a 3G Wireless network. Interworking these wireless networks require this customer be connected to the 3G network now, and it may also be desirable that the login to the new network be automated without even prompting the customer. The customer may then walk to another building served by yet another WLAN network. The 3G Wireless network will hand over the connection to this new WLAN network. The customer is authenticated to access this new network possibly behind the screen.

In (4-3), the customer using an application is moving from one network to another. The network needs to hang over the customer from one network to the different network without interruption of service to the active application. For example, a WLAN customer making a phone call in a building may walk to another building while the phone call is going on. The customer may find no WLAN service in between the two buildings, but the phone call can continue without interruption if the 3G Wireless service is available to bridge between the buildings.

6. CONCLUSIONS

There are different Wireless access networks, such as the PLMN family of networks, 802 family of wireless networks, broadcast networks, satellite networks, and ad hoc wireless sensor area networks. Interworking different wireless access networks and systems enables one to take advantage of and extend the usefulness of existing wireless systems. Interworking is an
enabling technology that will allow any customer of any service provider to run any communication application on any wireless communication device to communicate with any other customers. The underlying technologies for interworking involves internetworking, interoperability, mobility, security, QoS, etc.

REFERENCES