Volume 09 Issue 01 Published, February 17, 2005 ISSN 1535-864X DOI: 10.1535/itj.0901

Intel® Technology Journal

Second-Generation Intel® Centrino™ Mobile Technology

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Index words: EMA, VoIP, SNS, OBR, IRAP, WCS, VoIP, Bluetooth, 802.11, SIM, Roaming

ABSTRACT

Notebook computers based on the next-generation PC platform built on Intel® Centrino™ mobile technology are designed to meet and enhance the mobility requirements of a business user in the office as well as on the road. In this paper, we explore the capabilities of this platform, as well as the interfaces and the wireless ecosystem used to enable new usage models: Extended Mobile Access (EMA), Voice over Internet Protocol (VoIP), Simplified Network Selection (SNS), and One Bill Roaming (OBR). This next-generation platform is enabled to work with the EMA capability, which includes a small integrated display on the back of the lid that provides the user with up-to-the-minute calendar, daily tasks lists, and e-mail information while the user is in transit between meetings on the office campus while the notebook lid is closed. The EMA technology reduces the notebook power consumption by turning off the main LCD; hence saving battery life. The closed-lid notebook can still maintain network connectivity to the campus network via the Wireless Local Area Network (WLAN). The platform capabilities and the VoIP software will allow a user's desk phone to follow the user anywhere wireless or wired connectivity is available using VoIP. The latest platform incorporates the Wireless Coexistence System (WCS) Phase II solution that mitigates the potential interference between WLAN and Bluetooth[1]. Hence, the next-generation platform built on Intel Centrino mobile technology delivers a better audio experience for the user when used in the WLAN and Bluetooth environments. The platform includes SNS technology that enables end users to roam between WLAN and Wireless Wide Area Networks (WWAN) across multiple locations using a single set of Subscriber Identity Module (SIM) credentials and OBR across these heterogeneous wireless networks. Moreover, Intel Corporation is leading the industry to define International Roaming Access Protocols (IRAPs) [1], and in promoting adoption of IRAP. In essence, IRAP is a set of standards that are adopted by this next-generation platform.

INTRODUCTION

Notebook business users are looking for greater mobility in the office and on the road to engage in continuous business activities. The business user is looking for new powerful usage scenarios that enable continuous voice and data communications for access to e-mail, calendars, Personal Information Management (PIM), and desk phone facilities whenever a network connection is available. The next-generation platform built on Intel Centrino mobile technology makes this mobile digital office a reality and provides a better user experience. The following key capabilities are either enabled or provided:

- Extended Mobile Access (EMA) technology that provides users the ability to view new e-mail messages or view their calendar to find out where their next meeting is, through an integrated auxiliary display on the notebook lid when the notebook lid is closed. This technology improves users' productivity as the user roams inside the enterprise with the notebook lid closed.
- Intel's Wireless Coexistence System (WCS) Phase II technology provides a better user experience while receiving or making voice calls utilizing Voice over Internet Protocols (VoIPs) over WLAN with Bluetooth headsets. This technology enables VoIP soft phones on notebooks to provide a virtual office experience for the business user where the user's desk phone can be routed to the notebook as long as it is connected to the enterprise network.
- Simplified Network Selection (SNS) technology enables users to utilize WWAN SIM to roam to WLANs. This technology enables selection of the most cost-effective network among available networks without the user's intervention. The technology also enables a single bill model using One Bill Roaming (OBR).

To enable this on-the-go lifestyle of an enterprise mobile user, the wireless ecosystem around the platform must be enabled to provide a seamless connectivity experience to the user. In this paper we introduce the International Roaming Access Protocol (IRAP), which outlines this proposed wireless ecosystem.

EXTENDED MOBILE ACCESS FOR INCREASED PRODUCTIVITY

The next-generation platform built on Intel Centrino mobile technology enables Extended Mobile Access (EMA) hardware and software that has been developed to meet the requirements of the "Office Warrior" usage model, which describes the behavior of a user within a corporate office (enterprise) environment where 802.11 wireless connectivity is available. To support this usage model the EMA capability introduces a user interface on a small LCD with buttons to support navigation. The following are the key features available to an end user:

- *Closed-Lid Synchronization* that supports synchronization of Personal Information Management (PIM) data from a server to a local data store during closed-lid operation. The PIM data are current and available for viewing even if network connectivity is lost during transit.
- *PIM Mode* consists of continuous access to a server via a Wireless Local Area Network (WLAN) interface. The PIM data are updated continuously while the lid is closed and made available for viewing.
- *Network Detection and Status* indicates the status of the WLAN connectivity including Service Set Identifier (SSID) and signal strength.
- *Battery-Level Indication* provides information on the current battery strength of the notebook.

Figure 1 illustrates the EMA LCD on the mobile platform and the usage model.

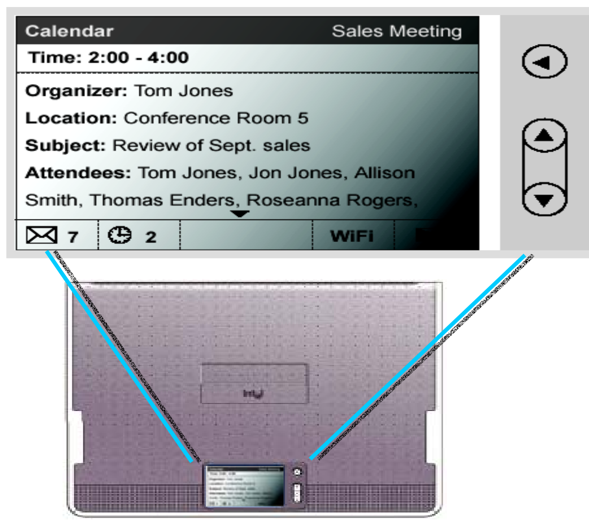

Figure 1: EMA usage model

Architecture

EMA technology consists of an operating mode that performs a number of functions such as powering down non-essential devices and synchronizing PIM information upon the closure of the notebook by the mobile user. Figure 2 provides an overview of the EMA architecture.

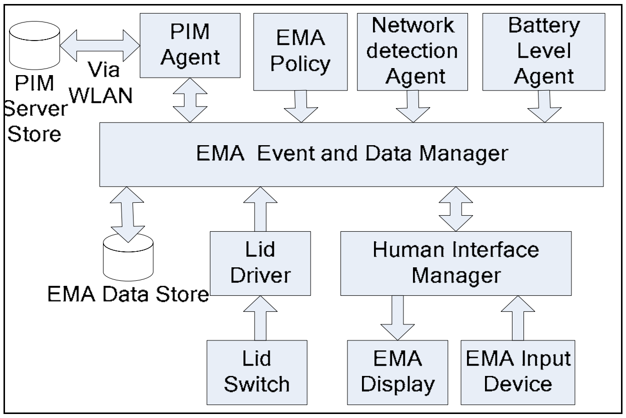

Figure 2: EMA architecture overview

This section provides an overview of the following key EMA subsystems and concepts:

- EMA Closed-Lid operating mode
- WLAN communication subsystem
- EMA display and input devices
- EMA agents: PIM, network, and battery

EMA Closed-Lid Operating Mode

The EMA policy manager is responsible for the policy settings and execution of closed-lid operations. The end user will be able to set policies to have the notebook enter EMA Closed-Lid operating mode and perform functions within this mode when the lid is closed (lid event). In this mode, subsystems that are not used are powered down to save energy. Table 1 lists the state of various subsystems under one possible policy configuration.

Table 1: Subsystems state

WLAN Card	On
Processor and Chipset (including memory)	On
HDD	On
Small EMA Display	On
Main LCD	Off
Wired Ethernet	Off
CD-ROM/DVD	Off
COM and LPT Ports	Off
Mouse and Keyboard	Off

The EMA Closed-Lid operating mode also employs processor performance control utilizing Intel SpeedStep® technology to implement a combination of processor P-state management and CPU throttling to reduce platform power and cap thermal dissipation of the notebook.

WLAN Communication Subsystem

EMA technology employs the WLAN IEEE 802.11 a/b/g communication framework for enabling closed-lid usage models. The WLAN interface provides connection to the PIM servers on the network to get continuous updates. One of challenges is to address Virtual Private Network (VPN) connectivity issues. In the enterprise, in some deployment models, WLAN is deployed outside the firewall. VPN connectivity is essential to maintain security of enterprise user data over WLAN. To initiate VPN connection, one has to enter a Personal Identification Number (PIN) into the notebook. In closed-lid mode this could be inconvenient. Intel Corporation worked with VPN vendors and enabled hands-free VPN connectivity for EMA closed-lid operation. The VPN connection persists as the user moves across Access Points (APs).

EMA Display and Input Devices

The fundamental feature of EMA is instant access to PIM data and status. A simple glance at the EMA display yields some useful information about unread e-mail messages, current calendar alerts, network connection, and battery status. The technology also will have buttons to allow the user to navigate through various menus and screens to view critical PIM data and status information about the WLAN and battery.

EMA Agents

When the lid is closed, the PIM agent clears any stale data in the EMA data store and establishes a connection with the PIM server using the WLAN interface; it then registers for new PIM updates and caches the data for viewing.

The network agent detects the WLAN environment including SSID, AP-friendly name, and signal strength and updates these details periodically in the EMA data store for viewing.

The battery agent continuously updates the battery-level indication in the EMA data store for viewing.

EMA Usage Model Extensions

The EMA technology can be extended to include new usage models in the future. One possible extension is to receive or make voice calls while users move about the office campus when the notebook lid is closed. The user

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can interact with the lid display and navigation buttons to accept or reject voice calls. The user also initiates calls using PIM data on the integrated display. The user experience can further be enhanced by using a Bluetooth headset in conjunction with closed-lid notebook for Voice over Internet Protocol (VoIP) applications.

Another possible extension to EMA technology could be a closed-lid usage model that utilizes speech recognition technology for speaker commands and control of notebook applications. While the closed-lid notebook user is mobile and wearing a Bluetooth headset, the user can access his/her voice mail, e-mail, and task and calendar items. The user can also get speech-based calendar and e-mail alerts through the Bluetooth-based headset while the user is on the go. Adding MP3 player features to EMA technology is desirable as users can listen to music while the lid is closed using Bluetooth headsets.

EMA Key Benefits

EMA features allow the notebook to run in a lower power profile without a full power drain on the battery and enable users to be more productive as they roam the office campus freely, while keeping up-to-the-minute with e-mails, tasks, and appointments. EMA enables the notebook to continue to provide access to critical information even while it is closed. The increased convenience of EMA will result in a new set of user needs and requirements. The next-generation platform built on Intel Centrino mobile technology establishes a foundation for these usage models, and the user experience will keep getting better with each new-generation platform.

ENABLING VOIP APPLICATIONS FOR BETTER USER EXPERIENCE

The "voice on the go" usage scenario is about supporting VoIP soft-phones on Intel Centrino notebooks for enterprise users. The soft-phones enable enterprise users to make calls to other soft-phones or Public Switched Telephone Network (PSTN) phones using VoIP technology as long as the user is connected to the enterprise network. This usage model allows users to replicate a virtual office environment on their notebooks, and as long as they are connected to the enterprise they will have access to their desk phone and all their telephone services including call transfer, speed dialing, conferencing, hold, access to voice-mail, etc. The value proposition of this usage model includes convenience for enterprise workers and also brings tremendous cost savings for IT.

This usage scenario allows the user to make and receive phone calls in any location with IP network connectivity as long as they are connected to the enterprise network. Users in most cases will be using WLAN to connect to their IP network and will use Bluetooth wireless headsets. VoIP over WLAN is a key capability that enables this "voice on the go" scenario. Due to the simultaneous use of WLAN and Bluetooth, the next-generation platform built on Intel Centrino mobile technology offers a Bluetooth/WLAN coexistence solution to support this usage.

When Intel launched PC platforms enabled with Intel Centrino mobile technology in 2003, the Intel Wireless Coexistence System (WCS) Phase I was implemented between Intel's PRO/Wireless 2100/2100A Network Connection solution and a third-party Bluetooth module [2] that mitigated Bluetooth interference and restored WLAN 802.11b data throughput almost completely. The following sections detail current problems, audio quality issues, and how WCS Phase II further mitigates RF interference.

Wireless Coexistence Problem Statement

Figure 3 shows a typical usage scenario for a VoIP application and illustrates how RF interference causes audio quality degradation. In this example, a "speaker" is talking to the "listener" using the left mobile PC via a Bluetooth headset. At the same time, the "speaker" is also sending some files or sharing some document with the "listener." In this scenario, the left mobile PC is receiving Bluetooth audio packets, and at the same time, it is transmitting files via WLAN. Since WLAN (802.11b/g) and Bluetooth use the same frequency (ISM band 2.4 GHz) at the same time, RF interference occurs in the left mobile PC. As a result, the listener at the right mobile PC will hear the corrupted sound.

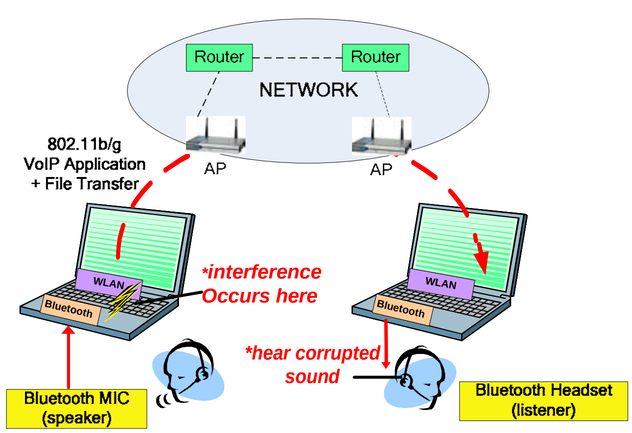

Figure 3: VoIP usage model

To further illustrate the problem, Figure 4 shows WLAN 802.11b/g and Bluetooth audio High quality Voice (HV) 3 Synchronous Connection-Oriented (SCO) packet activity over the time and frequency. The blue boxes represent Bluetooth HV3 packets, hopping between 2.40-2.48 GHz.

The red boxes represent 802.11b/g packets; in this case, it is operating in Channel 5. Since WLAN and Bluetooth operation are not coordinated, a collision happens when Bluetooth packets hop into the WLAN channel while WLAN is transmitting/receiving packets. Furthermore, since HV3 packets have no Cyclic Redundancy Checksum (CRC) in Bluetooth Version 1.1 [3], the corrupted packets will not be retransmitted.

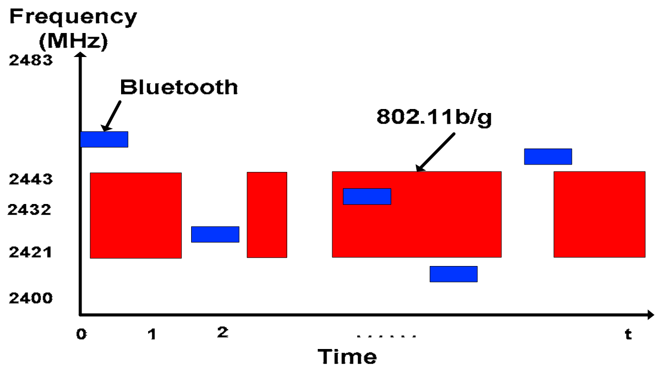

Figure 4: Uncoordinated WLAN and Bluetooth activities

Intel WCS Phase II Solution

In 2004, Intel developed PRO/Wireless 2200BG and 2915ABG Network Connection modules supporting 802.11b/g and 802.11a/b/g WLAN standards, respectively. Phase II of Intel WCS was also developed and implemented between these modules and third-party Bluetooth modules for the next-generation platform built on Intel Centrino mobile technology. The third-party Bluetooth modules include Cambridge Silicon Radio (CSR) BC02 and BC4, and RFMD SiW3000.

Figure 5 shows the Intel WCS Phase II interface diagram. There are two pins between the WLAN and Bluetooth modules: the CH_Data and the CH_CLK, which are multiplexed with Bluetooth priority data named BT_Priority. The general idea is that the WLAN module will send channel information to the Bluetooth module whenever it is active. Similarly, if the Bluetooth module is transmitting and/or receiving high-priority packets for audio, Human Interface Device (HID: mouse or keyboard), or link establishment, it will assert BT_Priority if the transmit/receive frequency is within the WLAN channel. The WLAN module then receives this signal and decides whether or not to hold off its transmission. This coordination is implemented in the Bluetooth and WLAN hardware and firmware; it is independent of the Bluetooth software stack, which is a key advantage of Intel WCS.

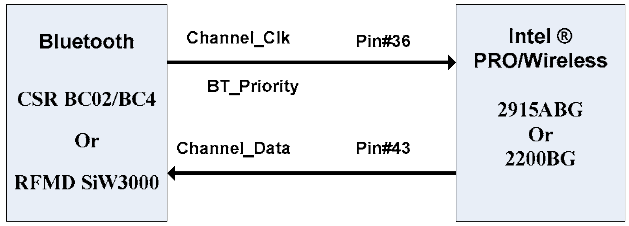

Figure 5: Intel WCS Phase II block diagram

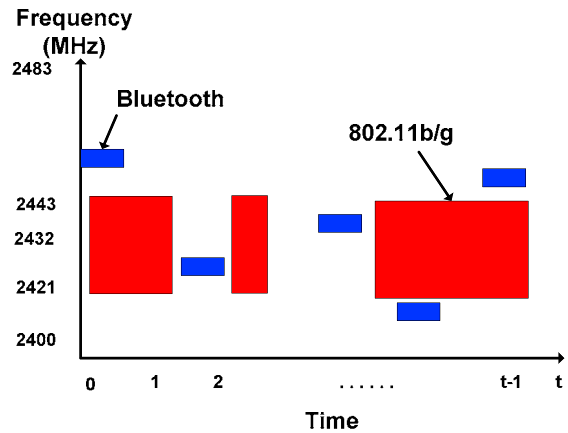

Figure 6: Coordinated WLAN and Bluetooth activities

With Intel WCS Phase II implemented, Figure 6 shows the modified WLAN 802.11b/g and Bluetooth audio HV3 SCO packet activity over the time and frequency. As shown in the figure, when a Bluetooth high-priority packet hops into the WLAN channel, the WLAN module will decide whether to hold off the packet transmission or not. By doing this, it reduces collision significantly, and Bluetooth audio quality is recovered.

Intel WCS Phase II Benefits

Now that the problem and solution have been described, let's look at what kind of benchmark is used to measure audio quality and to quantify Phase II's benefits. After investigating several audio benchmark tools available on the market, Opticom's OPERA* system was selected for several reasons. First, it adopts the latest international standard Perceptual Evaluation of Speech Quality (PESQ) for VoIP applications. Second, this tool is easy to use, and third, it is widely adopted by the cellphone industry. The OPERA system will generate Mean Opinion Scores (MOS), ranging from 0 to 4.5. A score of 4.0 or above signifies that the audio quality is good, 3.0-4.0 signifies that it is fair, and finally, 2 and below signifies that the audio quality is poor.

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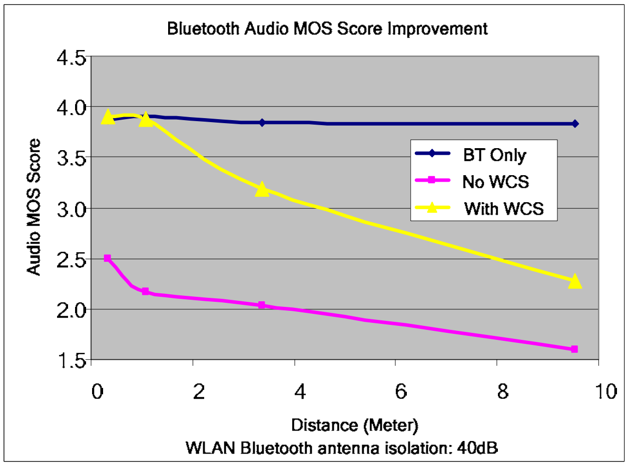

Figure 7: Bluetooth audio MOS

Figure 7 shows the audio-quality performance for a simulated VoIP scenario where the test system is cabled up. Indicated distances are calculated using path loss models. The key reason in utilizing a cabled-up system is to generate repeatable results. "Over the air" testing is subject to sometimes unpredictable RF interference, which could result in erratic test results. In Figure 7, the horizontal scale shows the calculated distance between the Bluetooth headset and the notebook with Bluetooth radio.

The Bluetooth audio streams are recorded using Windows* audio recorder and when compared with reference audio clips, MOSs are generated. For example, if there is only Bluetooth audio traffic in the system (i.e., no WLAN interference), audio quality is reasonable with the MOSs close to 4.0, up to about 10 meters. Then, with simultaneous WLAN traffic and Intel WCS disabled, the magenta line shows that even when the Bluetooth signal is strong, the MOS drops dramatically, starting from 2.5 and going down to 1.5. When Intel WCS Phase II is turned on, however, the yellow line shows that the Bluetooth audio quality improves significantly, especially at shorter distances where VoIP is anticipated.

Intel WCS Phase II's goal is to minimize the impact to WLAN performance while improving the quality of Bluetooth audio. The impact to WLAN performance due to Intel WCS Phase II is shown in Figure 8. The horizontal scale shows the calculated distance between the AP and the test notebook. The distance is calculated from the receiver signal strength and a path loss model for the office environment. The vertical line shows the WLAN throughput. Different color lines denote these three cases:

1. WLAN only–blue
2. WLAN with Bluetooth audio, but with Intel WCS Phase II disabled–magenta.
3. WLAN with Bluetooth audio, but with Intel WCS enabled–yellow line.

It is clear that the delta between the magenta and yellow lines is relatively small. In other words, the impact of the Intel WCS Phase II to WLAN performance is relatively minimal.

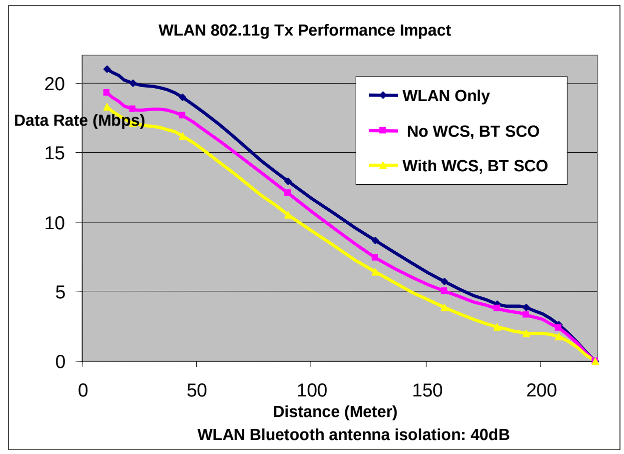

Figure 8: 802.11g throughput impact from WCS Phase II

Intel WCS Phase II Summary

Intel WCS Phase II helps to mitigate interference between WLAN and Bluetooth critical packets, such as packets for audio, HIDs, and link establishment. As a result, it helps to improve VoIP audio quality significantly when a user uses a Bluetooth headset and WLAN as the network connection. Furthermore, it has minimal impact on WLAN performance. Intel WCS Phase II works with legacy Bluetooth Version 1.1 devices, and it is also forward-compatible with Bluetooth Version 1.2 devices. In conclusion, the next-generation platform built on Intel Centrino mobile technology with Intel WCS Phase II provides a better user experience for VoIP applications using Bluetooth and WLAN technologies.

SIMPLIFIED NETWORK SELECTION

Simplified Network Selection (SNS) is an Intel initiative based on the International Roaming Access Protocols (IRAPs), Global Systems for Mobile Communications (GSM) Association, Internet Engineering Task Force (IETF) and 3rd Generation Partnership Project (3GPP) standards and forums under which Intel product teams developed SNS technologies such as the Extensible Authentication Protocol with Subscriber Identity Module (EAP-SIM) authentication method and the SIM Reuse client software, which is in compliance with the GSM

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SIM AT command and Smart Card interface specifications to provide end users with the ability to roam between different wireless network types (WLAN and WWAN) across multiple locations using a single set of SIM credentials. In addition to a common authentication model, this technology also enables a One Bill Roaming (OBR) mechanism across heterogeneous wireless networks. The next-generation version of the Intel Centrino mobile technology platform contains the Intel PROSet/Wireless Software v.9.0.0, dual-mode Wi-Fi 2200BG, or tri-mode Wi-Fi 2915ABG hardware modules. EAP-SIM/SIM Reuse features are part of the Intel PROSet/Wireless software v.9.0.0 that use SIM AT command or PC/SC interfaces to enable access to the user's credentials from a SIM contained on a WWAN card, a Smart Card, or a USB SIM reader.

Problem Statement

With many wireless technologies available today, wireless data users experience interrupted wireless service when roaming between wireless networks. The wireless users have to negotiate the different access mechanisms, manage multiple accounts, and receive multiple bills for wireless services. Improving wireless users experience by providing simpler, safer methods of access via a single set of credentials that can be used over different wireless network types has become an essential fact for wireless technology adaptation, and SNS addresses these issues to provide a compelling solution.

SNS Solution

The aim of the SNS solution is to give notebook users automatic, constant, and economical access to the Internet and corporate Intranet, whenever their notebooks are turned on. Constant and automatic access means that users do not have to go through a manual process of connecting to the Internet/Intranet and entering authentication credentials each time they need to communicate with a remote server. Economical access means that constant Internet connectivity will not impose a significant cost premium and will furthermore allow users to specify network selection based on cost. EAP-SIM/SIM reuse and OBR are two of the key features available in the next-generation version of Intel Centrino mobile technology notebooks.

EAP-SIM is an implementation of an authentication method for Wi-Fi roaming and network access, which is based on GSM technologies. It provides mutual authentication of the client device to the network, and the network to the client device, to ensure that only valid user devices gain access to the mobile telephony network. It features the use of a SIM card, a type of Smart Card, containing user information that can be used in accounting/billing procedures, as well as data that are used in the encryption of transmitted voice and data. SIM cards, though most commonly used in mobile phones, are emerging for use with laptops, notebooks, PDA handhelds, and other devices to integrate the WLAN and GSM-capable intelligent networks.

OBR is an added benefit when user notebooks have built-in WLAN modules and add-on/built-in WWAN modules with SIM reuse technology. With the same set of SIM credentials, a carrier is able to generate one single bill for users regardless of the network types.

OBR Architecture

Figure 9 illustrates the overall WLAN and WWAN inter-working Authentication Authorization and Accounting (AAA) protocol architecture for WLAN and WWAN roaming. The interface between the WLAN hotspot and the GSM home network is called the inter-working roaming AAA interface. This is based on RADIUS as shown in Figure 9.

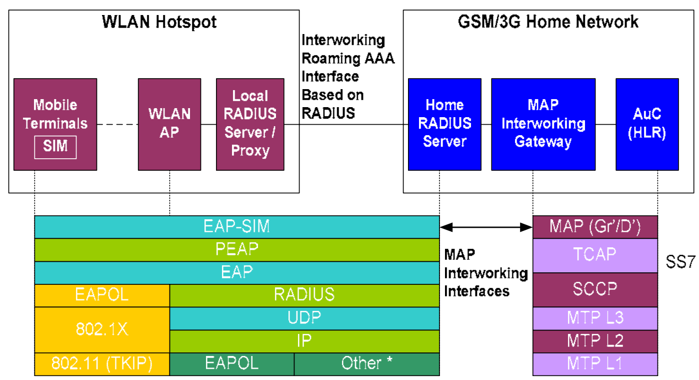

Figure 9: SIM based WLAN authentication protocol stack overview

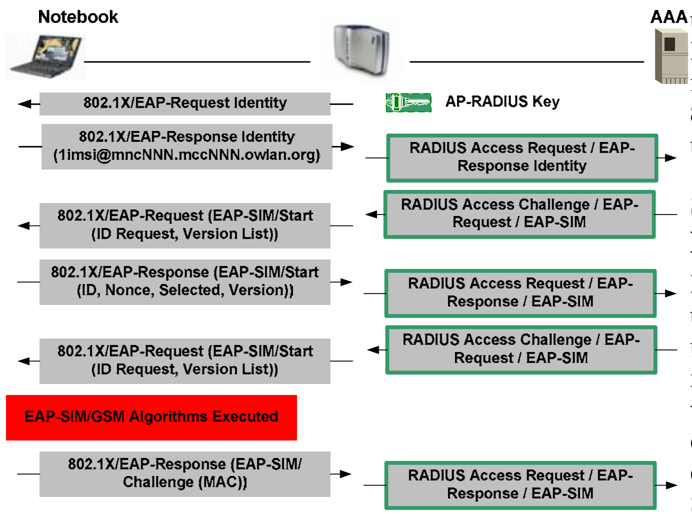

Figure 10: EAP-SIM authentication message flows

Figure 10 captures the high-level EAP-SIM authentication message flows between the mobile notebook, AP, and RADIUS server. The IEEE 802.1X protocol runs between the mobile notebook and the AP for the purposes of authentication. The Port Access Entity (PAE) implemented on the AP is responsible for blocking all user traffic except EAP packets until authentication completes. The AP also has a RADIUS client function that is responsible for initialing the RADIUS protocol that finally terminates on the home network RADIUS server, where the subscriber information resides. The RADIUS client is implemented based on the “IEEE 802.1X RADIUS usage guidelines” and is responsible for interpreting and appropriately forwarding the EAP packets between the AP and the home network.

Once the notebook associates with the AP, the EAP Over LAN (EAPOL) Start message is optionally sent by the notebook to trigger the 802.1X authentication process based on EAP. The EAP Identity Request is then sent to the notebook which responds with the EAP Identity Response that carries the NAI (username@realm). The “username” can be an International Mobile Subscriber Identity (IMSI) number or a temporary pseudonym, and the “realm” will be a fully qualified domain name that identifies the home network. The home network RADIUS server recognizing the “username” will attempt to start the EAP-SIM exchanges using the RADIUS Access Challenges/Requests. Following the successful authentication using EAP-SIM, the RADIUS Access Accept message sent from the server will result in an EAP Success message to the Client by the AP. This RADIUS message also carries EAP-SIM derived keying material for the session, which needs to be provided to the AP. The notebook also derives keying material as part of EAP-SIM authentication. Ciphering keys are set up using this keying material on the notebook and the AP as part of completing the 802.1X key-setting procedures. Please refer to the IEEE 802.1X, 802.11i and IETF EAP-SIM specifications for details on the key setting procedures [9,10]. The 802.1X PAE now opens the WLAN for user data traffic that is ciphered using the keys set up earlier.

SNS Real-Life Network Trial and Key Benefits

In 2004, Intel, selected carriers, and OEMs worked together and conducted successful end-user pilots. Pilot users have tested OBR usages for about four to six months in real-life inter-operator networks. One of the key things we learned from these pilots is that a user-friendly common connection manager is needed. Therefore, Intel enabled third-party Connection Manager Independent Software Vendors (ISVs) on next-generation platforms to meet users’ requirements.

The key benefits of the Intel SNS technologies are outlined below:

- They have the ability to automatically detect the currently available networks and optimize the connection for the best available network.
- They can authenticate/authorize and generate a single-bill model when roaming between WWAN and WLAN hotspots.

Intel SNS technology is also designed to address the mobile market segments and to provide enterprise-class features, security, manageability, seamless roaming across the enterprise networks and easy-to-use, zero-click enterprise connectivity at the office, home, or hotpots using EAP-SIM methods. Intel’s vision is to make notebook wireless data connection as easy as cell phone voice connection. The next-generation platform built on Intel Centrino mobile technology is the first step in realizing this vision.

PUBLIC WLAN ECOSYSTEM

Although the next-generation platform built on Intel Centrino mobile technology itself adds capabilities to enable new mobile usage models, it is essential that the platform operates seamlessly with the public WLAN ecosystem, which has grown immensely to support the mobile enterprise user on the road. IRAP addresses how the public WLAN (PWLAN) system is being enabled to work seamlessly in conjunction with this new platform.

Problem Statement in the Current Ecosystem

The analyst firm Gartner predicts by the year 2008 there will be more than 167 thousand hotspots in the world and over 75 million hotspot users. While the outlook for

PWLANs is promising, there are a number of obstacles that the industry must address for PWLANs to reach their full potential.

Current WLAN standards do not adequately address all of the system-wide issues that affect end-to-end roaming. Even vendors that are committed to a standards-based approach have developed implementations with incompatibilities with other vendors due to the ongoing evolution of standards and different choices of optional features. The rapid deployment of PWLAN currently results in a large installed base of fragmented and incompatible implementations. Fragmentation could increase the cost and complexity of supporting worldwide WLAN roaming to such an extent that it becomes difficult, expensive, and ultimately impractical to deploy. End users cannot count on their particular service experience being available at any particular hotspot and they face the possible dilemma of needing to re-configure their network devices to make use of these hotspots, while also negotiating varied login methodologies and authentication processes to be permitted to obtain access, and manage multiple bills for service. In addition, most of the current PWLAN security methods are insufficient for protecting data sent within a wireless hotspot. The challenges lie in the complexity of issues in the legacy network infrastructure, WLAN coverage, operators' business models, and billing and settlement requirements in a roaming context.

Today, service providers, equipment manufacturers, aggregators, and client manufacturers look at pieces of the solution focusing only on their individual product or offering without considering the entire PWLAN ecosystem. The solution lies in the adoption of a standards-based end-to-end architecture that addresses the technical challenges and facilitates ecosystem growth while improving the end-user experience (e.g., the next-generation platform built on Intel Centrino mobile technology). The solution to this problem is to follow the example of the cellular phone industry and enable PWLAN roaming. To solve these issues, Intel is working with wireless service providers, operators, and network equipment vendors from around the world [4, 5] to drive the definition and adoption of IRAP.

International Roaming Access Protocols Solution

IRAP [6] is an open framework to unify a global architecture. It is a set of core protocols that, when employed, make it easier for providers to build, test, and employ effective networks. The premise and goals of IRAP are to support secure worldwide seamless roaming by encouraging early alignment with and between existing and emerging standards. Users will be best served when there is a consistent service experience across all networks, logon is consistent worldwide, and there is one bill to pay and one method to access their network services and applications.

The IRAP framework defines a set of standards-based interfaces that establish a common baseline of features to facilitate seamless network interoperability between clients and different WLAN service providers. This framework is based on several architectural principles, co-existence between legacy browser-based authentication methods, and more secure authentication methods based on Wi-Fi Protected Access (WPA), end-to-end authentication and authorization, and a common accounting framework.

These interfaces are depicted in Figure 11:

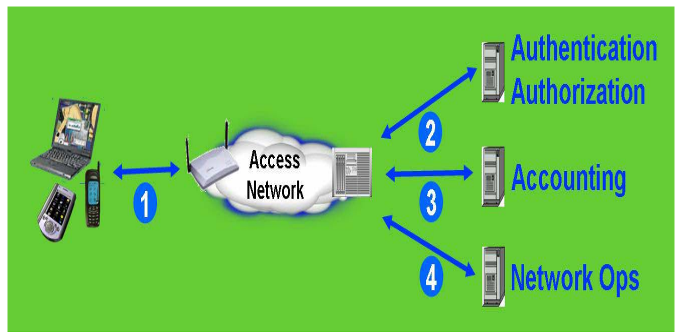

Figure 11: IRAP interfaces

Interface 1: Wireless Station to Access Network. This supports legacy browser clients and also enables the more secure and convenient next-generation authentication methods based on WPA/802.1X.

Interface 2: Access Network to Home Service Provider Authentication System. This supports AAA connections for authentication and service authorization between the visited hotspot network operator and the roaming user's service provider.

Interface 3: Access Network to Home Service Provider Billing System. This provides the accounting data to enable scalable and consistent OBR (a.k.a. unified billing) for multiple home operator types and billing models.

Interface 4: Access Network to Home Service Provider Operations Subsystem. This enables troubleshooting problems as they arise, via remote diagnostics. If customers are unable to connect in a visited network and contact their service provider, Interface 4 helps the service provider diagnose and resolve the problem.

IRAP Key Benefits

Adoption of these standardized interface profiles provides the following benefits:

- **Usability**. These profiles provide a common login process and allow the client to use a single set of credentials when roaming across PWLAN hotspots operated by different service providers.
- **Security**. The IRAP profiles improve security by encouraging adoption of (and providing a framework for) robust, over-air security and encryption methods. These methods include migration to WPA, which supports mutual authentication to protect both the user and the network, and higher security than the traditional browser-hijack methodology.
- **Interoperability**. The IRAP profiles prescribe a minimum set of accounting information that must be exchanged between different service providers. This allows the user to obtain a single bill from the home service provider regardless of the ownership of the visited networks to which they are connected.

These profiles facilitate easier integration between roaming service provider networks, and they enable end-to-end authentication between the client and its home service provider, regardless of the network being used.

IRAP Testing and Validation

As well as defining the technical requirements, Intel is driving the testing and validation of IRAP. By establishing interfaces within an ecosystem, IRAP facilitates points of verification where compliance can be confirmed. IRAP Conformance Tests [7] offer standalone tests for interface endpoints whereas IRAP Interoperability Tests validate the interoperability of two devices sharing an IRAP interface (e.g., interaction between a client and an access network).

In addition to conformance and interoperability tests, end-to-end testing [8] becomes increasingly important. With separate vendor networks interoperating with one another, the interfaces within vendors' networks must now interact with other roaming partner networks. Field trials [5], pilots, and deployment troubleshooting can be aided by running the IRAP end-to-end tests. The concept of end-to-end tests relates mainly to round-trip authentication and authorization (Interfaces 1 and 2) and billing support services (Interfaces 1 and 3). By creating and validating the plug-and-play vision of IRAP-based networks, deployment becomes more affordable, faster, and simpler.

SUMMARY

In this paper, we described new usage models for business users that are enabled by the next-generation platform built on Intel Centrino mobile technology. We have also demonstrated how this platform with the new capabilities increases users' productivity and efficiency while the user is in the office campus or away from the office. The key benefits are summarized as follows:

- EMA enables the notebook to continue to provide access to critical information even while it is closed.
- WCS Phase II Solution provides a better user experience for VoIP applications using Bluetooth and WLAN technologies.
- SNS is all about making it easier to connect to different wireless networks and providing single billing.
- IRAP adds a unified global infrastructure to the ecosystem to resolve seamless roaming obstacles and paves the way for new compelling usage models.

Some of the features that are discussed in this paper are pilot technology features and may not be supported on all the next-generation platforms built on Intel Centrino mobile technology. The platform with EMA, WCS Phase II solution, and SNS, in conjunction with the use of IRAP networks' secure authentication, authorization, roaming and seamless connectivity, allow the typical business user to be more productive by staying connected and synchronized.

ACKNOWLEDGMENTS

We acknowledge Duncan Glenndinning, Jeff Huckins, Glenn Olson, Asha Keddy, and Francis Truntzer for their help in writing this paper.

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