System Architecture for Billing of Multi–Player Games in a Wireless Environment using GSM/UMTS and WLAN Services

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ABSTRACT

Games played by multiple users, each using a wireless terminal (e.g., PDA), have tremendous revenue potential for next generation wireless systems. However, the next generation of wireless systems (such as UMTS and other 3G systems) alone will not be able to provide the tight delay bounds required by these multi–player games. We develop a system architecture that enables high–quality games among multiple wireless users and at the same time enables network service providers and game service providers to charge for the gaming service. Our architecture relies on *wireless vertical communication* conducted over UMTS to register (authenticate) the users at the commencement of a game and to report scores at the end of the game. During the game the players exchange information over *wireless horizontal communication* conducted over wireless LANs. Our architecture is particularly well suited for games that have off–line software distribution, but require a registration (authentication) each time the game is played. In this paper we describe our system architecture, which involves a UMTS–based Wireless Overlay Communication System (WOCS), and give the protocol for game initiation and score submissions. We also outline business cases for our system architecture and discuss the network provider's perspective.

Keywords

Ad–Hoc, Authentication, Billing, Business Case, Gaming, HOTSPOT, Multi–Player Games, UMTS, WLAN

1. INTRODUCTION AND MOTIVATION

Market research finds that mobile commerce for 3G wireless systems and beyond will be dominated by basic human communication (such as messaging, voice, video communication) and mobile entertainment (gaming, gambling) [4]. Messaging and voice services are already supported by 2/2.5G networks. Therefore it is questionable whether the network providers would get a sufficient return on their 3G investments by simply introducing one single new service. Likely, an array of several new services is required to convince customers to upgrade their wireless terminals, creating new market potential. This array of new services will probably include video services [6, 7] and also gaming.

Analysts predict that by the end of 2005, more than 200 million customers in the US and western Europe will play on–line games using wireless devices and that games will be one of the major driving forces behind the adoption of the 3G technology [21].

Today there is already a range of wireless games: 1.) simple single–player games that are built into mobile phones (e.g., the *Nibbler* on Nokia phones), 2.) simple and advanced single–player network games (e.g., chess against network computer via SMS [16, 12]), and 3.) two player games (e.g., *Tic–Tac–Toe* and *Mines* [20]). In contrast to the existing wired multi–player games (e.g., *Halflife*, *Age of Empires*, *Operation Flashpoint*) these games are very simple and less appealing. The reason for this big difference is the gaming platform and the network requirements. The multi–player games are played on PCs or laptops, which have larger display formats than the existing mobile phones. These popular multi–player games, however, require very tight jitter and delay, i.e., small ping times, which makes it very difficult to bring them into the wireless format. Typical strategic games, such as *Age of Empires*, require ping times below 300 msec, whereas typical fast shoot–em–up games, such as *Halflife*, *Counter Strike*, and *Operation Flashpoint* require ping times below 150 msec [8, 5, 15, 9]. (The bandwidth required by these games is typically small.)

In previous work [8] we have conducted measurements for the strategic game *Counter Strike* played over a wired LAN. For this wired scenario we have monitored the ping times (which are displayed on the players' screens) and the bandwidth requirements. We have observed that ping times below 150 msec provide a satisfying gaming experience. We also observed that the games typically generate small–sized packets, which calls for the compression of the networking protocol headers to achieve efficient transport. We also note that robust header compression should be used in the face

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of the typically frequent wireless link errors [3].

Wireless players that are connected to the Internet via a GSM air interface typically experience round trip delays around 2.4 sec [14]. Given the tight delay requirements for multi–player games [8], these large round trip delays make multi–player sessions over the GSM air interface impossible. Even though 3G wireless systems may provide smaller round trip delays, it is generally expected that they will still not meet the tight delay requirements of multi–player games.

In this paper we introduce a system architecture that enables high quality multi–player sessions in the wireless format for the customers and at the same time gives the network provider and the providers of multi–player games the possibility to charge for this new service. Our architecture is based on the UMTS technology in combination with WLAN technology. Our system architecture provides new possibilities for gaming support by substituting WLANs for UNTRAN into the UMTS core network. Our architecture allows for competition among players that are locally or globally distributed. Our architecture supports typical gaming features, such as automatic high score submission and skill level recalculation.

We emphasize that *multi–player* games are emerging as an extremely popular gaming form [16, 1]. These multi–player games are currently conducted over *wired* LANs or, in the case of the *Nintendo Gameboy* [17] over dedicated wires that are used to interconnect the individual Gameboy devices. Players report that multi–player games are much more fun than the existing simple wireless games. Indeed there is a strong trend towards organizing extensive competitions where several multi–player groups square off against each other. Incidentally these competitions offer large sums of money for the winning player team, additionally fueling the popularity of this gaming form [16, 1].

Our work on supporting multi–player (multi–user) games in *wireless* environments is motivated by two main factors. First, many players participating in multi–player games express interest in playing these games from a wireless platform, e.g., laptop or PDA, as this allows them to participate in the game without being tethered down by a wire. However, as pointed out above, the 3G wireless systems will not be able to meet the tight timing requirements of these games. In addition, the 3G wireless resources are expected to be too costly for the average player to afford. Our second motivating factor is that game service providers have found techniques to distribute the potentially large gaming software packages off–line. However, to activate the software, i.e., to start the game, the player needs to register with the game service provider. Similar to conventional arcade games which require a new coin every time the player wants to start the game, the players are required to register for each new instantiation (round) of the game. (In typical shoot–em–up games, for instance, each time the player is "dead", a new registration (authentication) is required to re–enter the game.) Our work provides a system architecture for the registration (and the corresponding billing) of wireless users. In our architecture, once a game is registered, it is played over a local wireless network (which is able to meet the required tight delay requirements).

2. SYSTEM ARCHITECTURE

Our framework consists of five main entities:

- the `Multi-Player Network`,
- the `Wireless Overlay Communication System (WOCS)`,
- the `Billing Entity`,
- the `Gaming Service Provider`, and
- the `IP Backbone`.

In this section we introduce these entities. We describe their functionalities and the communication flows between them. The five entities and the communication flows between them are illustrated in Figure 1.

Multi–Player Network

The multi–player network is used by a multi–player group. The multi–player group consists of multiple users. By definition all users forming a multi–player group want to play the same game together. Each user in a multi–player group has one wireless terminal for the game. The wireless terminals in the multi–player network have at least one (possibly multiple) *common* air interface(s) (as detailed below this condition may be relaxed in the HOTSPOT scenario).

The *common* air interface (e.g., IEEE802.11 [11], HiperLan2 [10], Bluetooth [2]) is used for the communication among the wireless terminals, which we define as *horizontal* communication. At least one wireless terminal in each multi–player group must have a connection to the WOCS (except in the HOTSPOT scenario, see below). In contrast to the *horizontal* communication we define the interface towards the WOCS as *vertical* communication. The terminal which was chosen (because of its capability) to communicate over both the *vertical* and the *horizontal* connection is referred to as *Bridging Terminal*. The bridging terminal runs the *Local Game Server*. The local game server supports a given multi–player group.

A multi–player network is characterized by its topology and the type of connection to the WOCS. The topology may be an ad–hoc topology or a cellular topology. (The terminals in the multi–player group may run any common type of wireless protocol for communication within the multi–player group.) We consider a topology that involves communication over multiple wireless hops as an ad–hoc topology (i.e., in the ad–hoc topology some terminals can not "see" the bridging terminal and thus require multiple hops to communicate with the bridging terminal). We define a cellular topology as a topology where all players in the multi–player group can communicate in one hop (i.e., directly) with the bridging terminal. The connection to the WOCS may be wireless or wired. In the case of the wireless connection to the WOCS the multi–player group may be formed anywhere within the coverage of the WOCS. In contrast, in the case of the wired connection to the WOCS, the multi–player group may only be formed at a location with an installed infrastructure; which we refer to as *HOTSPOT* [13] infrastructure (e.g., installed in airports, train stations, etc.). We note that the HOTSPOT infrastructure may be installed and controlled by the WOCS provider. We note that in the HOTSPOT scenario, there is no bridging terminal. Instead, there is an access point which is part of the network infrastructure.

In Figure 1 three possible multi–player networks are illustrated (the grey shaded area gives the coverages of the individual multi–player networks):

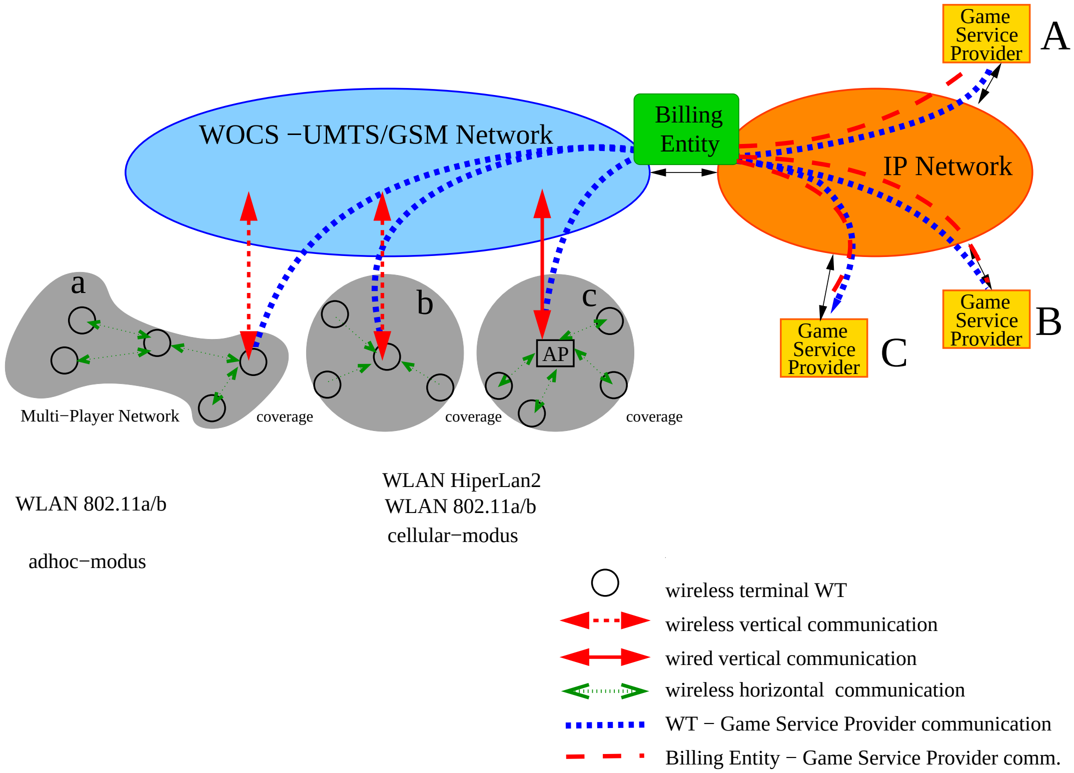

Figure 1: Vertical and horizontal communication structure for a multi–player gaming session with billing

- Network a) is a wireless *ad–hoc* network (based for instance on IEEE802.11) with a wireless vertical connection to the WOCS.
- Network b) is a wireless cellular network (based for instance on IEEE802.11, HiperLan2, or Bluetooth) with a wireless vertical connection to the WOCS.
- Network c) is a wireless cellular network (based on IEEE802.11 or HiperLan2) with a wired vertical connection to the WOCS (e.g., a wireless cell with a wired HOTSPOT server).

We note that in the HOTSPOT scenario the multi–player group is not restricted to players in the coverage area of the WLAN around the HOTSPOT server, but may include remote players connected to other HOTSPOTs. This is because the wired vertical connection provides multi–player game requirements in terms of low delay and low jitter (compared to the wireless vertical connections). Thus, with the HOTSPOT infrastructure the location distribution of the players is not restricted by the performance limitations of the wireless vertical connection.

Wireless Overlay Communication System

The wireless overlay communication system (WOCS) enables wireless terminals with the adequate air interface to connect anytime and anywhere within the coverage of the WOCS via the IP backbone network to the game service providers. The WOCS contains one billing entity. (The functionality of the billing entity is described in the next subsection.) The WOCS has to be able to connect to the IP backbone and at least to one of the wireless terminals of each multi–player network (except in the HOTSPOT scenario, in which the access point provides a wired connection to the IP backbone). In this paper the terms "WOCS provider" and "network provider" are used interchangeably.

The WOCS enables secure wireless downloading (off–line, i.e., before the game starts) of new games or game data (e.g., extension to the game, such as new tools and new maps) offered by the game service provider to wireless terminals.

Furthermore, if the WOCS supports location services it can facilitate the forming of multi–player groups. A player that wants to join a multi–player game may establish a wireless vertical connection to the WOCS to inquire about ongoing gaming sessions in the vicinity. The WOCS may respond by pointing the prospective player to the currently ongoing gaming sessions in the area and giving their location and the type of air interface used by these multi–player networks. Note that the prospective player needs the interface to the WOCS (e.g., UMTS) to use this service.

Billing Entity

The billing entity is part of the WOCS infrastructure. There are several scenarios for the billing procedure. We outline the two following billing approaches:

Separate Billing With separate billing the customer has a contract with the WOCS provider and one or multiple separate contract(s) with one or multiple game service provider(s). The WOCS provider charges the customer for the use of the wireless vertical connection (through the billing entity of the WOCS). There

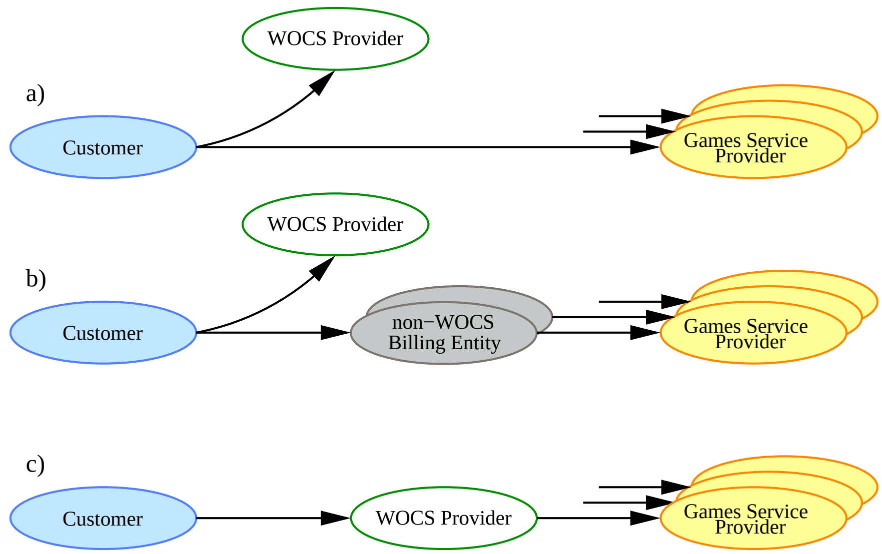

Figure 2: Illustration of separate billing with direct charging a), separate billing with indirect charging b), and transparent billing c)

are two scenarios for the charging for the gaming service. In the *direct* charging scenario (illustrated in Figure 2a)), the game service provider(s) directly charges the customer for the gaming services using either a pre–paid plan or a on–line credit card charge. In the *indirect* charging scenario (illustrated in Figure 2b)), a non–WOCS billing entity within the IP backbone charges the customer for the gaming services. This non–WOCS billing entity may provide billing services for the gaming services for a number of game service providers. Note that separate billing may be viewed as customer unfriendly, as the customer is being billed by multiple companies. An additional disadvantage of the separate billing approach is that the authentication of the customer, which is inherently provided by the WOCS through the customer's SIM card, can not be used by the game service provider (or the non–WOCS billing entity).

Transparent Billing With transparent billing (illustrated in Figure 2c)), the WOCS billing entity is used both for the billing for the vertical connection as well as for the billing for the gaming service. The two main advantages of the transparent billing approach are that (1) the customer deals only with one company (i.e., the billing for the gaming service in transparent to the customer), and (2) the customer's SIM card can be used for reliable billing. Therefore, the transparent billing approach may be viewed as customer friendly. Note that for transparent billing, communication between the WOCS billing entity and the game service provider is necessary to establish the price of the service (this however is transparent to the customer).

We note that both the transparent billing approach as well as the separate billing approach are inspired by the successful service model of NTT DoCoMo [18, 19]. NTT DoCoMo offers Internet services to the customers over its *i–mode* platform. NTT DoCoMo takes responsibility for the network infrastructure. The services for the platform are provided partially by NTT DoCoMo and partially by selected partners. The idea of the business model is that NTT DoCoMo receives the traffic revenue and the service providers receive their transaction revenue. In case the providers are using NTT DoCoMo's value–added services, such as billing, NTT DoCoMo also receives the revenue from the transactions (similar to our transparent billing approach).

We also note that the billing of remote players that are directly connected to the IP backbone and participate in HOTSPOT multi–player groups, is beyond the scope of this paper.

Game Service Provider

The game service provider (in Figure 1 three different game service providers A, B, and C are illustrated) authenticates each user for each new instantiation of the game either (1) directly (in the separate billing scenario), or (2) indirectly through the WOCS billing entity (in the transparent billing scenario). After the authentication the game service provider activates the requested game. The game itself runs on the wireless terminal and not on the game service provider's computing facilities. The game service provider is collecting the score results of the multi–player gaming sessions. The score keeping by the game service provider enables competitions among the players as well as among groups of players.

We assume that there are mechanisms in place to ensure that the players are not able to bypass the authentication. These mechanisms are typically implemented in the gaming software residing in the client. We note that these mechanisms may be light–weight and do not need to completely eliminate the possibility of a player "hacking" into the game. It will typically be sufficient if the mechanisms ensure that the percentage of "hackers" is low. We also note that the "hackers" are not able to participate in auxiliary gaming services (such as the scoring) as long as they do not break into the game service provider's computing facilities.

IP Backbone

The IP backbone is the Internet with standard IP services. Both the WOCS and the game service providers are connected to the IP backbone. In addition, the non–WOCS billing entities for indirect billing are placed in the IP backbone.

3. PROTOCOL FOR GAME INITIATION AND SCORE SUBMISSION

We now outline the protocol for the initiation of a game and the score reporting. We assume that the WOCS is implemented by a GSM/UMTS network. Furthermore, we assume that the multi–player network is implemented using any wireless LAN technology, such as IEEE802.11, HiperLan2, or Bluetooth. Terminals may simply be a laptop or an enhanced PDA with the appropriate network interface(s). As illustrated in Figure 3, the setup of a multi–player session proceeds in the following steps:

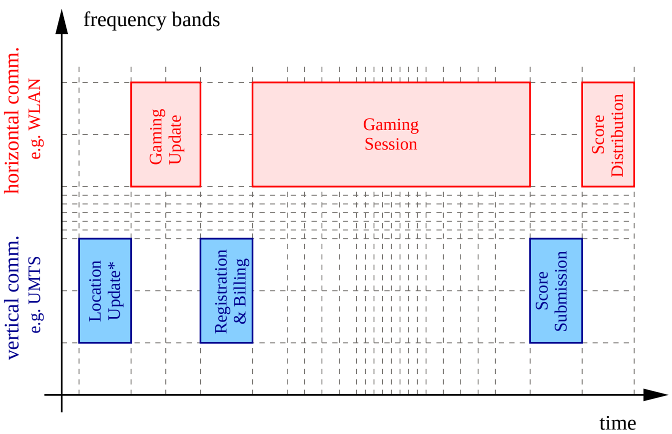

Figure 3: Time line of multi–player gaming session.

1. First, the multi–player group is formed. If the players know each other (e.g., kids on a playground) they use their *common* WLAN network interface to invite the session. But it is also possible that players are found by using the location–based services of the WOCS. In this case each player's terminal has to be equipped with the *vertical*, e.g., UMTS, as well as the *horizontal* communication interface. After having located the players using the location update services provided by UMTS (over the UMTS frequency band), they have to move within the coverage of the *horizontal* WLAN communication. The coverage of a multi–player network could be extended using ad–hoc (multi–hop) WLAN technology. To complete the formation of the multi–player group, one terminal is chosen to function as the bridging terminal and also to run the local game server. Recall that the bridging terminal must be able to connect both over the vertical connection and the horizontal connection. If there are multiple terminals with this capability in the multi–player group, then one of the terminals is chosen as bridging terminal according to some arbitration algorithm (which may take the terminals' computing and communication capabilities into consideration).

2. After having formed the multi–player group all terminals need to update/assimilate their gaming data (game/maps/functionalities). This update is done via the *horizontal* WLAN connection (in the WLAN frequency band). In case some wireless terminal has already this data, the terminal distributes the data among the other terminals. In case none of the terminals has the data, the bridging terminal downloads the data from the game service provider and then distributes it among the other terminals.

3. After the synchronization process the game has to be activated for one gaming unit. Therefore the bridging terminal with the vertical connection logs on to the game service provider via the WOCS and authenticates (registers) for playing the game with a specific number of players. After having been charged for the service the *vertical* connection is canceled. The bridging terminal may split the cost for the game among the players in the group and collect charges from the individual players. The details of the local charge collection is beyond the scope of this paper. In the HOTSPOT scenario, each of the players in the multi–player group is charged individually. We note that players with a SIM card may either be charged using the separate billing or the transparent billing approach. Players without a SIM card, on the other hand, may not be charged using the transparent billing approach (which relies on the SIM card) and hence may only be charged using the separate billing approach.

4. Now the game starts and the information for the game is transmitted via the *horizontal* connection. Thus, the WOCS resources are not wasted. Furthermore, the *horizontal* connection satisfies the quality of service requirements of the multi–player game.

5. If the game is over and one of the players or the entire group achieves the high score the vertical connection has is re–established and the high score is submitted to the game service provider.

6. The final score is also distributed among the terminals in the multi–player group using the horizontal WLAN connection.

7. In case the players want to play again they will be charged again.

Importantly, the vertical communication resources are only used for the "administrative" aspects of the game (i.e., forming the player group, authentication, billing, score reporting). The actual gaming traffic is exchanged via the horizontal communication. From the WOCS provider's perspective, the actual gaming traffic is "outsourced" to the WLAN.

4. BUSINESS CASES FOR MULTI–PLAYER GAMES

In this section we outline business cases for the different combinations of multi–player network topologies and their vertical connections. The quality and type of the multi–player game that may be played depends on the topology of the multi–player network. A cellular topology enables

Table 1: Business cases for different combinations of topology and vertical connection.

	Vertical Connection	
Topology	Wireless	Wired (HOTSPOT)
Ad–Hoc	Parking Lots Traffic Jams	Theme Parks
Cellular	Summer Camps Cruise Ships	Airports Train stations

games with higher QoS requirements (in terms of bandwidth and delay), i.e., shoot–em-ups, while the ad–hoc topology (which typically involves communication over multiple wireless hops) enables only strategic games with lower QoS requirements.

We now outline some promising business cases for the different combinations of topologies and types of vertical connections. The business cases are summarized in Table 1 and illustrated in Figure 4. A typical scenario with an ad–hoc topology and a wireless vertical connection may arise on expansive parking lots or traffic jams on highways where players are distributed over an area larger than the coverage area of the bridging terminal, as illustrated in Figure 4I. A typical scenario for a cellular topology and a wireless vertical connection arises when kids are in a summer camp (e.g., camping on a primitive camp ground without wired infrastructure). In this scenario we envision that the kids are located fairly close to each other, e.g., in neighboring tents, allowing them to communicate in one hop with the bridging terminal, as illustrated in Figure 4III. A similar scenario may arise on a cruise ship where people are located fairly close together, but do not have any wired infrastructure. In the cruise ship scenario, the vertical connection may be established with a UMTS satellite link.

Next consider scenarios with an installed wired HOTSPOT infrastructure. We envision that an ad–hoc topology with a wired vertical connection will, for instance, arise in expansive theme parks with a sparse HOTSPOT infrastructure and people playing games while waiting in line for various rides at different locations. A typical example for a cellular topology with a wired HOTSPOT infrastructure will arise in airports and train stations with a dense HOTSPOT infrastructure, where the terminals are always within the coverage area of the access point.

5. THE NETWORK PROVIDER'S PERSPECTIVE

The advantages of our architecture to the customers and the game service providers are obvious. Our architecture enables customers to enjoy high–quality multi–player games in the wireless format while enabling game service providers to charge for the games. We now proceed to examine the advantages of our architecture for the network provider, which may appear a bit subtle at a first glance. However, our architecture provides important advantages for the WOCS provider. Generally, 3G wireless systems (such as UMTS) and WLANs are viewed as competing technologies. Each of these technologies has its respective strengths (security and billing in 3G systems, high–speed service in WLANs) and weaknesses (limited bandwidth service in 3G systems, no billing infrastructure in WLANs). Thus each of these technologies provides a good platform for a specific set of services (moderate bandwidth services with accurate billing, e.g., for voice communication, over 3G systems, on the other hand, high–speed data services without billing, e.g., e–mail, over WLANs). Our architecture combines both technologies and provides a new service by building on the respective strengths of the two technologies. This "collaboration" between 3G systems and WLANs brings important advantages for both the 3G–based WOCS operator and the WLAN operator. Specifically, our architecture enables high–quality multi–player games that 3G technology alone could not support, thus opening up new revenue streams for 3G providers. The underlying design philosophy of our architecture is to "outsource" the bandwidth demanding on–line gaming traffic to WLANs while keeping the moderate–bandwidth administrative functionalities (such as billing, authentication, score reporting) inside the 3G system. We note that our outsourcing strategy is designed to give the WOCS provider a large return on the 3G investments. Specifically, our strategy allows the WOCS provider to charge a large fee per byte of traffic that is transmitted over the wireless vertical connection. At the same time, our strategy keeps the gaming affordable for the users as only the "administrative" traffic is routed over the wireless vertical connection.

6. CONCLUSION

We have developed a novel system architecture and a protocol for the support and the billing of wireless multi–player games in wireless environments. Our design brings significant advantages for both the customers and the network/game providers. The customers can enjoy a new gaming form, which can not be supported by the GSM/UMTS interface. For network providers, our design opens up the possibility to offer new revenue–rich services (known in the wired world) in the wireless format. Both the network service provider and the game service provider can charge the customers using our billing infrastructure. An important feature of our system architecture is that the actual gaming traffic is transmitted over the horizontal communication links (using the un–licensed frequency band). The network providers resources are only used for authentication (registration) of users, billing, and the exchange of gaming scores. Loosely speaking, in our system architecture the actual gaming traffic is outsourced to WLANs and the UMTS network is only used for "administrative" functions (similar to the functionality provided by the BIOS in a PC). We have outlined a number of promising business cases for the different types of horizontal and vertical connections.

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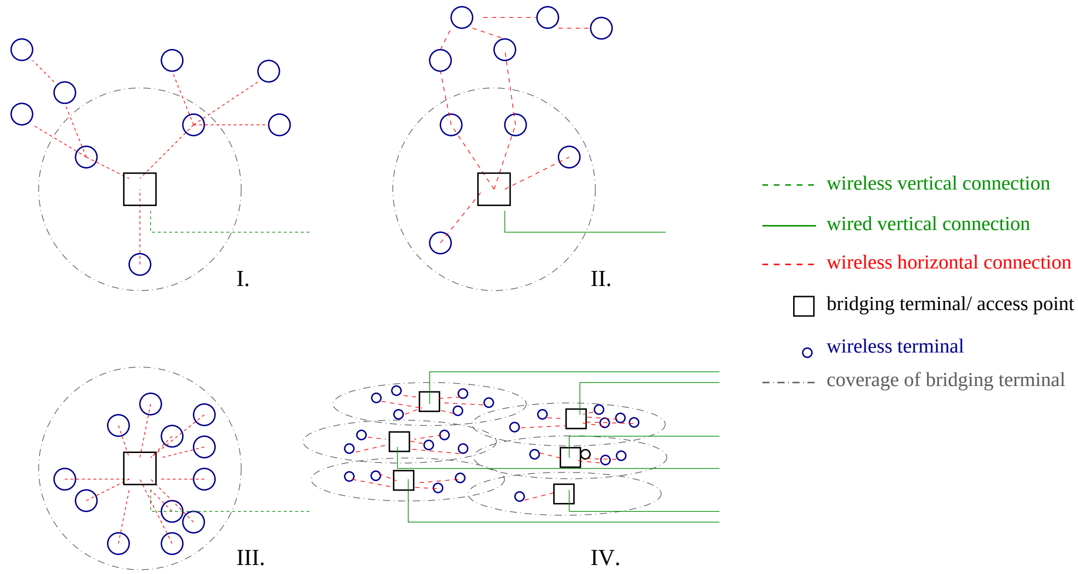

Figure 4: Illustration of business cases.

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