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Power Saving in Mobile Handover Networks Using Simple Protocol Architecture

Anandakumar.H
Assistant professor, Department of Information Technology
SNS College of Engineering, Coimbatore-641 107, Tamilnadu, India

Abstract*— *Instant messaging (IM) is a form of communication over the Internet that offers an instantaneous transmission of text-based messages from sender to receiver. Mobile instant messaging (MIM) is the technology that allows instant messaging services to be accessed from a portable device, ranging from standard mobile phones. But in MIM frequency exchange of presence information causes massive power consumption to mobile devices. Such power consumption penalty can render persistent-instant messaging infeasible for battery-powered mobile devices. In this paper, I try to propose solution to mitigate the power consumption problem. The proposed solutions are implemented using SIMPLE protocol; it is one of the instant messaging protocols. It is the extension of SIP (Session Initiation Protocol) protocol. Actual power measurement results show that the power consumption of the proposed solutions agrees well with the analysis, and significant power saving can be achieved on mobile handsets with the low power consumption solutions implemented.

Index Terms: **Mobile Devices, Power Consumption, and Simple Protocol.**

I. INTRODUCTION

INSTANT messaging (IM) services, as have become arguably one of the most popular Internet applications nowadays, appeared as early as the introduction of the UNIX operating system, where users were able to exchange short messages using simple commands in real time. It is not, however, until the advent of ICQ (short for "I seek you") that IM began to gain wide popularity. Within only a few years, commercial IM applications such as AOL Instant Messenger (AIM), Microsoft MSN messenger (MSN), and Yahoo! messenger [1], were released one after another with millions of registered users today [2]. Typically, IM applications provide two main services: the instant message delivery service and the presence awareness service. The instant message delivery service enables real-time text message exchange between users, while the presence awareness service provides the instantaneous online status of IM friends/entities through the so-called "buddy list" [3].

Originally, IM services are designed and tailored for desktop use only. It is commonly realized that modifications to the existing IM services are necessary before IM can be widely accepted by mobile users [4]. Issues that have been identified for mobile IM include enhancement for presence awareness and security [5], [6], [7], [8], support for location awareness [9], and the power consumption problem [10]. To the best of the authors' knowledge, however, the issue of power consumption caused by running IM on mobile devices has not been specifically addressed and solved. As shown in [10] and [11], sporadic data traffic on mobile devices leads to sever power consumption penalty. The occasional behavior of presence exchange with remote IM friends/entities thus poses a problem, which, as show in this paper, can render persistent-IM infeasible for battery-powered devices.

In this paper, propose several solutions to lower the power consumption of mobile devices due to the presence information exchange. By effectively reducing the rate of the presence information exchange that mobile devices actually have to participate in, the proposed solutions are capable of achieving great power saving at zero cost. Further power saving can also be obtained on the mobile devices by compromising a certain amount of presence update delay. The tradeoff between the presence update delay and the attainable power saving is derived analytically in this paper. The proposed solutions are then implemented on both Wi-Fi and 3G handsets using a SIMPLE/SIP Protocol based on which extensive power measurement experiments are performed. It is observed that the analysis is accurate in capturing the amount of power saving provided by the proposed solutions. By yielding an average presence update delay of 30 seconds, maximum power savings of 6.5 mA and 154 mA can be achieved for handsets over Wi-Fi and 3G networks, respectively. Concerning the battery capacity of mobile handsets, which typically ranges between 700- 1,500 mAh, proposed low power consumption solutions can effectively extend the battery lifetime for mobile IM users.

The remainder of this paper is organized as follows: in Section 2, describe the mobile IM system on which we will explore the problem of power consumption, including the power saving mechanism and various presence ex-change mechanisms. In Section 3, propose the corresponding solution to lower the power consumption to each type of presence exchange mechanism. In Section 4, a SIMPLE/SIP protocol based implementation of the proposed solutions is presented along with the power measurement results. Finally, conclusions are given in Section 5.

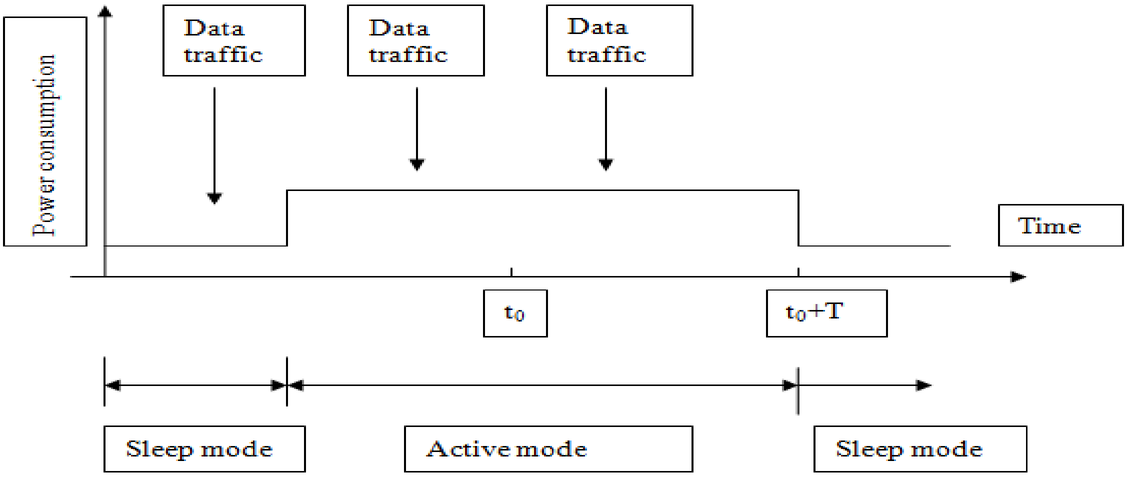

Fig 1: Transitions between the active and sleep modes on mobile devices.

II. SYSTEM DESCRIPTION

In this paper, a battery-powered mobile device which persistently logs onto one or multiple IM services since the majority of the IM traffic consists of the presence information exchanges, we focus only on the power consumption due to the presence information exchanges. It is assumed that there is no text message exchange taking place during the power measurement. As mentioned previously, the online status of remote friends changes from time to time. An IM client regularly exchanges messages with remote entities, either a central server or other peer clients, to ensure its current presence information always being up-to-date. Such frequent network access severely disrupts the power saving mechanism of the mobile device. Depending on the underlying protocols, the presence information exchanges affect the power saving mechanism in different manners. In this section, first describe the power saving model of a typical mobile device. This model is simple, yet it captures the essence of the power saving operation. Then elaborate on the various mechanisms for exchanging presence information.

A. Power Saving Model

The operation of a typical mobile device can be roughly classified into two different modes: the active mode and the sleep mode. In the active mode, all the communication modules are turned on to support data exchange at low latency. On the other hand, during the sleep mode, the mobile device turns off the RF and other communication modules until it wakes up again to process data traffic. The mobile device consumes battery energy at a much higher rate in the active mode than in the sleep mode. The longer the mobile device stays in the sleep mode, the more power it saves. The procedures for mobile devices to transit from the active mode to the sleep mode generally differ in implementations. Yet, they share similar features. In general, if a mobile remains idle for a certain period without seeing any data traffic, it will enter the sleep mode. In this paper, assume the mobile device switches from the active mode to the sleep mode when a fixed amount of waiting time T has elapsed since the last data exchange. An illustrative example is given in Figure 1.1.

B. Presence Exchange Mechanisms

Most IM applications such as AIM, MSN, and Yahoo! messenger are proprietary services. As a result, they have interoperability problem. Though some efforts have been done on standardizing the IM protocols [12], [14], [15], it is often the case that different IM services implement different presence exchange mechanisms. While being different, IM presence exchange mechanisms can generally be classified to either one or more than one of the following presence exchange mechanisms. Figure 2.1 shows the presence update mechanism of IM.

1 Event-Triggered Presence Update

This presence exchange mechanism requires that a presence update message being broadcast to all of the remote entities when an IM client manually changes its own online status. This mechanism serves as a notification to the remote friends of the instantaneous presence change and is implemented in almost all IM services. As IM users typically have a large number of remote friends, receiving event-triggered updates comprises the dominant portion of the presence information exchange in IM.

2 Presence Probe

In this mechanism, an IM client initiates a probe message to a remote IM entity to request an online status update. When the remote entity receives the probe message, it replies to the sender with the requested information. For example, it is observed in our network experiments that a Skype [16] client generates probe messages to the peer clients on its friend list every 180 seconds. Note that for a mobile client, the power consumption induced by initiating presence probes can be larger than that induced by reacting to presence probes. This is due to the fact that the initiating party must wait for the response from the remote entity to return, whereas the requested party can enter the sleep mode immediately after it reacts to the probe. However, since the round-trip delay between the mobile clients is usually small as compared with T, we assume both cases consume the same amount of battery energy in this paper.

3 Periodic Presence Update

In this case, an IM client periodically sends (receives) messages to (from) the remote entities. The message could be either an explicit presence update or simply a dummy message checking the validity of the connection. For example, it is observed in the experiments that an MSN client generates a packet every 29 seconds to the centralized MSN server to report its presence. It is worth noting that when a mobile device logs onto multiple IM services, it must conform to each of the IM protocols and execute the associated presence exchange mechanisms of each IM. As a result, the power consumption generally becomes higher in this case.

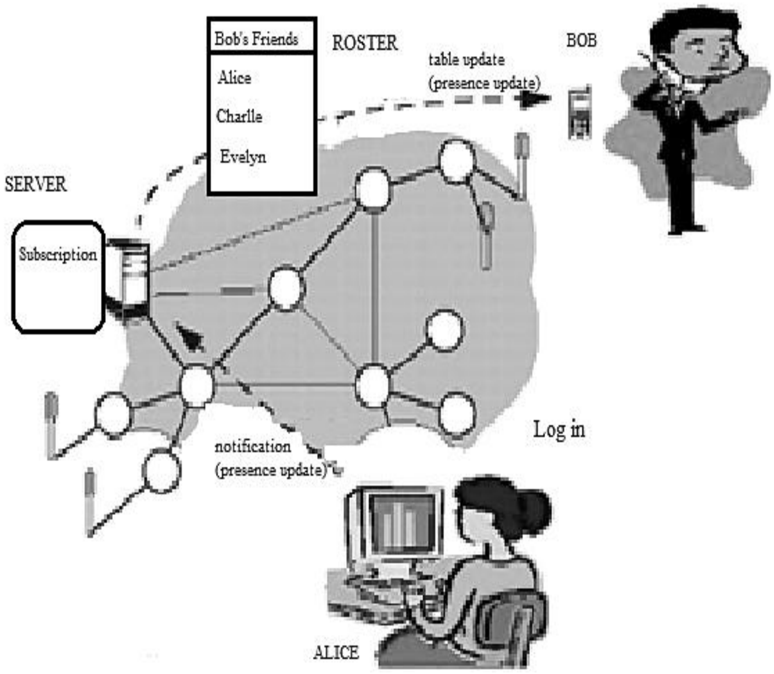

Fig 2: Presences update mechanism of IM.

III. POWER CONSUMPTION ANALYSIS

In this section, first derive the power consumption for the considered mobile device both with and without the proposed solutions to compute the achievable power saving. The expected presence update delay experienced by the mobile client after applying the proposed solutions is then derived to characterize the tradeoff between the attained power saving and the resulted presence update delay.

A. Power Consumption for Presence Information Exchange

Typically, presence update messages contain only the user account and online status information. The length of presence update messages and the associated transmission time is rather small as compared with that of the regular network data traffic. Assume the transmission time is negligible so that a presence exchange triggers the modem to stay in the active mode for exactly T seconds. The power consumption of the mobile device is then completely determined by the arrival process of the presence information exchanges, which is in turn characterized by the inter arrival time distribution of the presence exchanges.

Table.1: Notations

T	**Inactive timer value.**
$\mu_{i,k}$	**Rate of outgoing presence information due to mechanism I of IM protocol k.**
$\lambda_{i,k}$	**Rate of incoming presence information due to mechanism I of IM protocol k.**
P_a	**Power level of mobile device at active mode.**
P_s	**Power level of mobile device at sleep mode.**

Let *tp* denote the time duration between two consecutive presence information exchange.The cumulative distribution function of *tp* can expressed as

$F_{tp}(t) = 1 – \Pr \{ t_p > t \} \approx 1- \exp (- \sum_k (\lambda_{1,}k + \lambda_2,k +\mu_2 ,k) t)\prod_k (1 – \min \{ \lambda_{3,k}t , 1 \}) (1- \min\{\mu_{3,k} t , 1\}$ (1)

The last equality shows different presence mechanisms are nearly uncorrelated. Let *Ta* and *Ts* denote the respective burst time that the mobile device persistently stays in the active mode and the sleep mode. It is clear that $Ta \geq T$. It can be shown that the proportion of time staying in the active mode for the mobile device is

$$f_a = \frac{E[T_a]}{\left(E[T_a]+E[T_s]\right)} \tag{2}$$

One needs the value of *fa* to compute the power consumption incurred by presence information exchanges. Define *n* to be the number of presence information exchanges within *Ta*; *n* is geometrically distributed as GEO ($1-ft_p(T)$). We can express *Ta* as

$$T_a = \sum_{i=1}^{n-1} t_i + T \tag{3}$$

Where *ti* denotes the *i*th inter arrival time of the presence exchanges, and $\{t_i\}$ are independently and identically distributed as $tp \mid \{t_p \leq T\}$. It should be noted that in (3), neglected the possible paging delay introduced by the first presence exchange after waking up from the sleep mode. Such approximation is acceptable since the paging delay is relatively small as compared with the inter arrival times $\{t_i\}$. Taking the expectation of (3), it can be shown that

$$E[T_a] = \left(\frac{1}{p} - 1\right) E[t_p \mid t_p \leq T] + T \tag{4}$$

On the other hand, since $Ts = Tn - T$ is just the remaining time for the next presence exchange event to occur given that a period of *T* has elapsed, we have

$$E[T_s] = E[t_p \mid t_p > T] - T \tag{5}$$

Combining (1), (4), and (5), we can rewrite (2) as

$$f_a = \frac{E[t_p \mid t_p \leq T](1-p) + T_p}{E[t_p]} \tag{6}$$

$$= \frac{\int_0^T 1 - F_{tp}(t)dt}{\int_0^\infty 1 - F_{tp}(t)dt}$$

Using the notations in Table 1, the additional power consumption due to the presence information exchange on the mobile device can be derived as

$$(P_a - P_s)\, f_a \qquad (7)$$

The additional power consumption incurred by running IM on the mobile device with the proposed solutions applied is, thus

$$(P_a - P_s)\, f_a' \qquad (8)$$

Finally, the attainable power saving P_{saved} of the proposed solutions can be obtained easily from (7) and (8) as

$$P_{saved} = (P_a - P_s)(f_a - f_a') \qquad (9)$$

IV. SYSTEM IMPLEMENTATION AND POWER MEASUREMENT RESULTS

Here present the implementation of the proposed mobile IM power saving solutions, by using the SIMPLE protocol. Introducing agent between the instant message server and mobile can save power. It accumulates the presence information and delivered to the user after the threshold time. I am going to perform the simulation in SIMPLE Protocol; it is one of the instant messaging protocols. It is the extension of SIP (Session Initiation Protocol) protocol. It provides two modes of instant messaging, page Mode and session mode. Page Mode uses SIP method message and it does not uses sessions. Session Modes uses the MSRP (The Message Session Relay protocol), it allows both instant messaging simultaneously. Using SIMPLE MSRP protocol one can send large number of text messages. The Session Initiation Protocol (SIP) provides all of the functions needed for the establishment and maintenance of communications sessions between users. One of the functions it provides is a registration operation. A registration is a binding between a SIP URI, called an address-of-record, and one or more contact URIs. These contacts URIs represent additional resources that can be contacted in order to reach the user identified by the address-of-record. When a proxy receives a request within its domain of administration, it uses the Request-URI as an address-of-record, and uses the contacts bound to the address-of-record to forward (or redirect) the request. The SIP REGISTER method provides a way for a user agent to manipulate registrations. Contacts can be added or removed, and the current set of contacts can be queried. Registrations can also change as a result of administrator policy. For example, if a user is suspected of fraud, their registration can be deleted so that they cannot receive any requests. Registrations also expire after some time if not refreshed.

Table 2: Average Current Consumption of various IM Services

	Wi-Fi	**3G**
	POWER	**POWER**
MSN	**7.6mA**	**204mA**
Yahoo!	**4.8mA**	**158mA**
AIM	**5.5mA**	**155mA**
Google Talk	**6.5mA**	**201mA**

In the implementation part, there is SIP along with the agent to reduce the Power Consumption. Table 4.1, Shows the Current Consumption of various IM. SIP will control the communication between the access point and the mobile device. And the agent will try to reduce the time to time exchange of online status. It is nothing but presence. It is equal to indication of availability of communication. A user, a device or some resource offer some ways to communicate: Do I want to pick up the phone call? Can you talking to your friend by video cam? Where is the college you need to find? Are there any free seats in the meeting room? And so on. The presence information includes means, ability, capability, status, willingness and location. By publishing presence information, it is getting easier to contact people or to utilize resource. Meantime, it helps the current service offering much better service according to customers' different presence status. While reducing the presence exchange it will generate some delay in the mobile device. But it will control the radio signals propagate from the device. Hence reduce the power consumption. The Instant messages Architecture consists of Client-Server Connection. Show in the Fig 3. The implementation part of this paper is between the Access point and the mobile device.When receiving a presence update message, the PDA handsets stay in the active mode for another timeout period with much higher power consumption than that in the sleep mode as described in Section 2. For the PDA handsets we used, both the cellular modem and the operating system software wake up during the timeout period and contribute to the high power consumption.

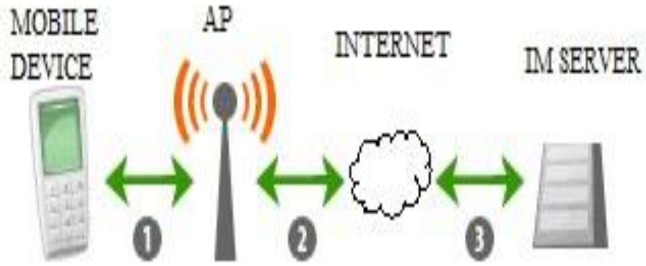

Fig 3: IM Architecture Diagram.

A simple solution could be forcing the operating system to enter the sleep mode as soon as the reception of a presence update message. The results of the power consumption measurement using “Agilent 66321D Mobile Communications DC Sources” are listed in Table 2. Note that the results are given in units of current consumption (mA) as output by the measuring instrument. The corresponding power consumption can be obtained by multiplying the current consumption value by 3.6 volts, which is the operating voltage level of the tested mobile handsets. All the measurement results represent the average additional current consumption incurred by running a particular IM service. For my proposed solutions, the proxy-induced presence update delay is targeted at 30 seconds. We can see that the power consumption incurred by the original IM architecture is quite prohibitive, especially in the case of 3G. This is due to the highly inefficient implementation of the mode transitions in 3G/UMTS networks. The waiting time for 3G mobile handsets to enter the idle mode can potentially exceed tens of seconds [11]. In my experiments, a timeout value T of 14 seconds. On the other hand, it is shown that significant power saving can be achieved for all IM services once the proposed solutions are applied. Specifically, for the measurement results over the Wi-Fi network, it is observed that the power consumption values due to IM services are all reduced to around 1 mA. A maximum power saving of 6.5 mA is achieved. As to the 3G network, the power consumption values are all reduced to around 55 mA, and a maximum power saving of as high as 154 mA can be achieved. Concerning the battery capacity of mobile handsets typically ranges between 700-1,500 mAh, our proposed low power consumption solutions can effectively extend the battery lifetime for mobile IM users. In Figs. 4 and 5, the analytical curves of the tradeoff between the attainable power saving and the mean presence update delay are plotted along with the measurement results for MSN over Wi-Fi and 3G networks, respectively. One can see that the measurement results agree well with the analytical results. It can also be observed that our solutions are able to provide power saving gain at zero presence update delay. This is due to the fact that the proposed solutions completely remove the need to initiate presence probes and periodic presence updates from the mobile device. Depending on the user preference, one can determine the operation mode of the handset by compromising between the tolerable presence update delay and the desired degree of power saving. It is observed that the proposed solutions can achieve even higher power saving for the case of multiple IM services. This is due to the fact that the power consumption resulted from the multiprotocol overhead is removed once the proposed solutions are applied.

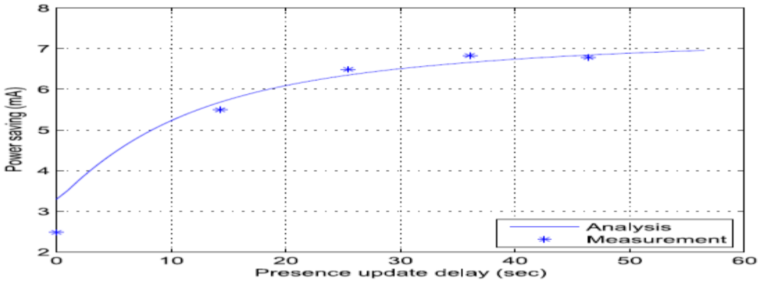

Fig 4 : The tradeoff between the attainable power saving and the mean presence update delay for MSN over Wi-Fi networks.

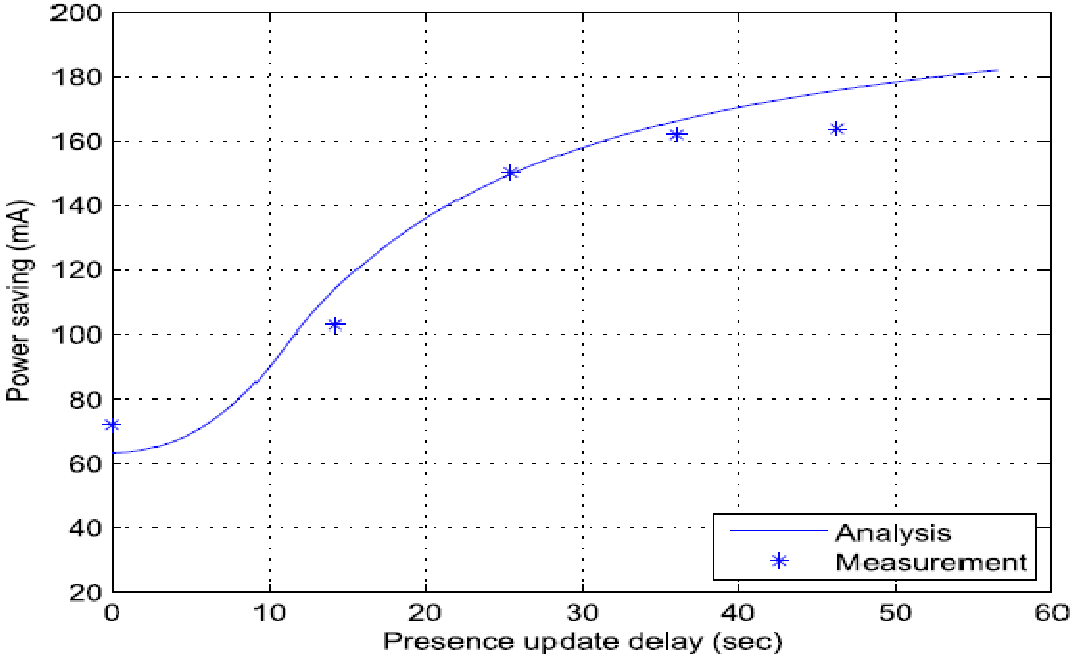

Fig 5 : The tradeoff between the attainable power saving and the mean presence update delay for MSN over 3G networks.

V. CONCLUSION

In this paper, I have investigated the power consumption caused by the presence information exchange of IM on mobile devices. To analyze the severity of this problem, examine the various presence information exchange mechanisms and derive the respective power consumption implications proposed several mobile IM power saving solutions to reduce the power consumption penalty. The proposed solutions achieve power saving by introducing agents to reduce and regulate the presence information exchange traffic. The proposed proxy-based IM architecture has been implemented using the SIMPLE/SIP protocol. Actual power measurement experiments have been conducted and the results coincide well with analytical work. The proposed solutions together with the analyzed tradeoff between the presences update delay and the power consumption can be applied to implement adaptive power saving mechanism for mobile IM services by adjusting the tolerable presence update delay in real-time according to the remaining battery life. The handset battery life can be effectively extended with the balance between the presence update delay and the attainable power saving.

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AUTHOR BIOGRAPHY

H.Anandakumar Finished his Master Degree in Software Engineering, from PSG College Of Technology Coimbatore, And Working As Assistant Professor in Department Of Information Technology, SNS College Of Engineering Coimbatore. Research Interested In Mobile Communications and Networking Protocols.