Mobile Data Traffic & WiFi Offloading – Briefing Paper

Introduction and Market Trends

The use of smart phones and other mobile devices is changing how we access the Internet. Gone are the days when you had to go to the home office, boot up the PC or laptop, get a cup of tea, login, go for a second cup while the computer started all essential and non-essential services, come back and finally launch your preferred browser to access the Internet.

The new generation of mobile devices are easy to handle and are designed for instant access to the Internet. It takes less than 5 seconds on an iPhone or iPad to start the Internet browser.

Furthermore, the way we consume content over the Internet is changing. The Internet is feeding us with bits of information such as low resolution videos designed to fit on smaller screens. Social networking sites allow us to post messages including pictures and short videos. Many major content providers have a web-site that automatically adapts the content to smaller screen sizes and for everything else we go to the App Store or equivalent.

In short, many drivers are pushing Internet users towards mobile devices and these changes in consumer behaviour are having an impact on mobile networks and the companies who run these networks. These trends will dramatically increase mobile data traffic, requiring a lot of additional resources to satisfy the demand for instant mobile data access. Most of the research reports are predicting an increase of mobile data traffic by a factor of 30 in the next 5 years (2009-2014). Here are few numbers that put this trend into perspective:

- Cisco forecasted that
  - Global mobile data traffic will double every year through 2014, increasing 39 times between 2009 and 2014.
  - The number of mobile-only data users will increase from 12.8 million in 2009 to 635.8 million in 2014. This number only takes the top 13 countries in the world into account, but it shows the tremendous increase in mobile data traffic that is expected over the next 4 years.
  - Global mobile data traffic will increase from 0.09 exabytes in 2009 to 3.6 exabytes per month by 2014. 1 exabyte is 1,000,000,000,000,000,000 bytes = 10^{18} bytes = 1 billion gigabytes = 1 million terabytes.
  - 66% of world’s mobile data traffic will be video by 2014.
AIB Research forecasted that 48% of mobile data will be off-loaded by 2015. Additionally, mobile data traffic will grow by a factor of 30 meaning off-loading will expand by 100-fold by 2015.

O2 UK reported that its mobile data traffic in Europe doubled every three months in 2009. We assume that many other operators see a similar increase.

AT&T reported that its mobile traffic increased 5000 percent in the past 3 years.

Equipment vendors such as Ericsson, Nokia Siemens, Huawei, etc. will improve the situation through technical innovation (new compression algorithms, more effective traffic management, etc.). Re-allocation of end-of-life radio frequencies (e.g., analogue TV, 2G radio spectrum) will improve the situation and will increase the capacity of 3G/4G data networks. However, mobile network operators will not be able to satisfy the forecasted demand by deploying standard cellular 3G/4G network infrastructure.

Mobile Network Operator Data Offload Strategies

Most of the mobile operators have introduced and started to implement a mobile data offloading strategy. In other words they will have to find complementary technologies for delivering data originally targeted for 3G/4G networks.

The capacity to carry large volumes of traffic over radio waves is the most challenging aspect. It would be possible to increase the capacity for large mobile cells. However, costs, environmental aspects and especially radio interference issues will make this option less attractive. For this reason the operators are introducing very small radio cells to deliver the required capacity and coverage. These cells are characterized by transferring large volume of data over a very short distance. We are talking here about a distance of 10 to 40 meters.

Two technologies, WiFi and Femtocells have emerged as the preferred offloading technologies. A third technology, WiMax, is also emerging. In this paper we focus on the WiFi offloading technology and present the 3GPP I-WLAN architecture in more detail. The I-WLAN standard proposes a loose integration of WiFi access networks with mobile operator networks. This approach is less complex and less expensive than previously proposed architectures that were tightly integrated with the 3G infrastructure.

WiFi Offloading

The following figure provides a simplified view of networks and nodes that play key roles in handling mobile data traffic using traditional 3G communication and the WiFi access network to off-load traffic from the 3G access network.
Figure 1: 3GPP I-WLAN Architecture

On the left side of figure 1 we show a mobile device and two wireless access networks, a WiFi access network and a 3G access network. These networks are available to the mobile phone user for accessing the Internet.

In general the mobile user will select the WiFi access network to communicate with the Internet because it offers a higher bandwidth and it is also beneficial to the mobile operator because the traffic is off-loaded from the 3G network that has limited resources. The 3G network is only used if the WiFi network is not available. This approach is already used by many mobile users when they connect to the Internet. However, in most of the cases the WiFi access network communicates with an Internet Service Provider (ISP, not shown in this diagram) meaning the mobile operator looses the control over the mobile user and can not offer premium services to the mobile user nor charge for the data transfer. In other words revenue is lost from the mobile user and from the content provider.

The middle part of the diagram depicts the mobile operator infrastructure that is required to integrate the access networks with the backend system. The 3G infra-structure is illustrated by the SGSN and GGSN nodes. The bottom part shows the new I-WLAN nodes that allow the mobile operator to establish a controlled communication channels between the WiFi user and the content provider. The new I-WLAN nodes are explained in further detail below. Both approaches may or may not share the same infrastructure for authentication, charging and Quality-of-Service (QoS).

The basic idea of the I-WLAN architecture is to establish a controlled tunnel between the mobile device and the infrastructure of the mobile network operator. Controlling this tunnel or channel allows the operator to offer better services but also to charge for these services. As mentioned earlier, this path is controlled by the fixed line ISP.

WLAN Access Gateway

The WLAN Access Gateway is responsible for routing the data to/from the WLAN Access Network and the Packet Data Gateway. It is the first node that
interacts with the WiFi network. The WLAN has many functions. The most important are listed below:

- Makes sure that packets are routed to the PDG.
- Supports QoS mechanism if they are applied. This would allow operators to guarantee bandwidth if the users purchased such a service.
- Discards data packets that shall not be forwarded to the PDG. This will reduce the load on the PDG and the packet data networks.

**Packet Data Gateway (PDG)**

- Responsible for the authentication of a mobile device and the authorization to select services.
- Resolves and assigns an IP address for the mobile device.
- Maintains routing information for the mobile device.
- Filter out unauthorized traffic.
- Generates charging information related to the user data traffic.
- Applies QoS mechanisms that allow operators to provide policy-based control for different users and traffic types.
- Routes traffic to/from packet data networks. Premium service (e.g., high definition video) may use the high-quality network while less demanding services (e.g., reading email) will use the best-effort Internet.

The packet data networks and content providers are shown on the right side of the diagram. Two different networks are used to connect to content or data providers. We use the term ‘Internet’ to provide a best effort communication service, while the High-Quality-Network is used to provide guaranteed bandwidth for premium services (e.g., high definition video, high-speed backup service, etc.).

Distinguishing between best-effort services and high-quality services is desirable because it will allow the mobile operator to charge for premium services such has high-quality video, while lesser services can be offered for free or for a minimum fee

**I-WLAN Mobile Operator Benefits:**

- Offload low-end services away from expensive 3G access network, which will free up capacity for mobile users who are on the move.
- Increase coverage via WiFi cells and reach mobile consumer at home or in the office.
• Provide higher bandwidth and hence better services.

• Control the customer experience.

• The operator is able to implement a charging model that is policy-based and takes the type of traffic, the requested quality and traffic volume into account.

• Control traffic usage and implement a fair usage policy.

• Increase revenue by taking on mobile users that previously used other fixed line providers.

I-WLAN Mobile Subscriber Benefits:

• Subscriber is able to select premium services that guarantee a certain quality.

• Improved access to the Internet at home or in the office by using the WiFi access network.

• Improved access to the Internet while on-the-move because the capacity of the 3G network increased due to off-loading.

WiFi Offloading Outlook

The I-WLAN standard provides the mobile network operators with a standardised and controlled approach to off-load traffic over Wi-Fi networks. It gives them control over traffic that originated via a WiFi network and integrates it into their backend systems. It does not address the finer aspects of seamless roaming between different network types. Currently, it is not possible to initiate a call on a WiFi network and continue the call on a 3G network.

The implementation of such a feature requires new thinking and more intelligence needs to be pushed onto mobile devices. Mobile devices not only have to select the strongest radio signal, they also need to implement new communication protocols that allow an application to route voice or data traffic transparently across different networks paths.

Recent research projects have investigated the possibility of using SCTP (Stream Control Transmission Protocol) to implement a reliable transport over wireless networks. The multi-streaming and multi-homing features of the SCTP protocol could be used to implement seamless roaming between two different wireless network types (e.g., WiFi and 3G).

SCTP was originally designed by IETF to implement reliable telephony signalling protocols (SS7) over IP. SCTP is also used as a transport between various LTE nodes, e.g., eNodeB and MME. Furthermore, LTE is used for the Diameter protocol in LTE.

Implementing such a capability would provide the ultimate user experience and could be an important differentiator for mobile network operators.
## Acronyms

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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>3GPP</td>
<td>3rd Generation Partnership Project; a collaboration of telecommunications companies and groups to provide global mobile phone specifications.</td>
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<td>GGSN</td>
<td>Gateway GPRS Support Node (GGSN); the GGSN is a key node of a mobile operator’s network and it is responsible for the interworking between the GPRS network and external packet switched networks, like the Internet.</td>
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<td>GPRS</td>
<td>General packet radio service (GPRS) is a packet oriented mobile data service on the 2G and 3G cellular communication systems for mobile communications.</td>
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<td>I-WLAN</td>
<td>Interworking Wireless LAN, a 3GPP acronym for integrating WiFi networks into mobile operator networks.</td>
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<td>IETF</td>
<td>Internet Engineering Task Force, a forum that develops and promotes Internet standards.</td>
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<td>IP</td>
<td>Internet Protocol</td>
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<td>ISP</td>
<td>Internet Service Provider</td>
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<td>LTE</td>
<td>Long Term Evolution, the latest 3GPP standard for radio access networks providing downlink peak rates of 100 Mbit/s, an uplink of 50 Mbit/s.</td>
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<td>PDG</td>
<td>Packet Data Gateway; a node of the 3GPP I-WLAN infrastructure</td>
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<td>QoS</td>
<td>Quality-of-Service</td>
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<td>SGSN</td>
<td>Serving GPRS Support Node; the SGSN is</td>
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<td>SS7</td>
<td>Signaling System No. 7, a set of telephony signaling protocols</td>
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<td>WiFi</td>
<td>A synonym for wireless access network technology based on the IEEE 802.11 standard.</td>
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