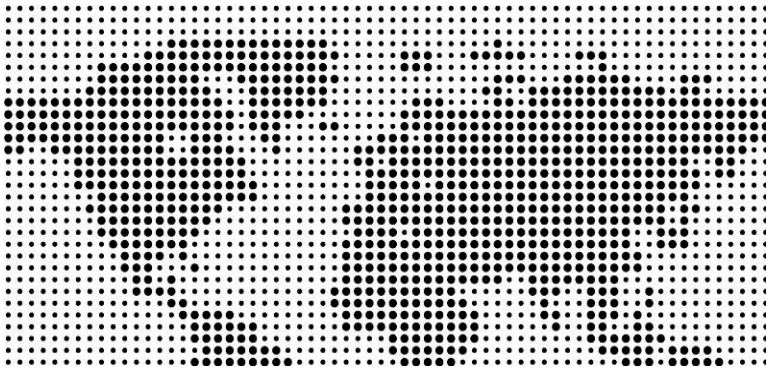
3G/Wi-Fi Seamless Offload



Qualcomm Incorporated
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[1] Introduction

The number of wireless subscribers accessing mobile data services continues to increase. Third Generation, or 3G, has been adopted and gained traction rapidly due to a variety of developments, including the:

- Wide-spread availability of mobile broadband services using USB modems and data cards at affordable prices
- Increasing penetration of 3G-enabled smartphones such as the iPhone, BlackBerry phones and Android phones
- Plethora of smartphone applications
- Flat rate plans
- Widespread deployment and coverage of 3G data networks

These developments will continue to drive the increase of mobile data traffic volume. However, they could also create challenges for 3G operators in supporting traffic growth, particularly when licensed spectrum is limited.

Mobile data traffic consumption continues to increase rapidly. Wi-Fi capacity can become a seamless extension of 3G.

In order to cope with this traffic growth, operators can use traditional mechanisms to expand network capacity. But these often entail high cost investments. Since data service value is detached from the traffic volume, it creates pressure on the deployment costs. The operator challenge is in developing pricing models that maximize revenue per MB and deploying networks that minimize cost per MB. In this environment, intelligent resource management provides a cost-effective way to support the data traffic growth by optimizing network use, balancing the network load, lowering network congestion, and delaying CAPEX investments.

Since WLAN is widely available at home and various hotspots, and is also in a number of 3G devices, a mechanism that offloads data traffic from 3G to Wi-Fi is very compelling to operators that want to minimize data costs and make better use of their assets.

This paper is focused on a solution called 3G/Wi-Fi Seamless Offload, which enables seamless handover of data traffic between 3G and Wi-Fi, as well as the possibility to move selective IP traffic (i.e., HTTP, video, VoIP, etc.) while supporting simultaneous 3G and Wi-Fi access.

[2] The Role of WLAN

Since WLAN is widely available at home and through various hotspots, and is also in a number of 3G devices (i.e., smartphones, laptops, netbooks) that typically consume a large portion of resources, a mechanism that offloads data traffic from 3G to Wi-Fi is very compelling to operators that want to minimize the data cost and make better use of their assets.

The basic idea is whenever a WLAN access point is available, some or all of the traffic is routed through the WLAN access point, thus offloading the cellular access.

Mobile operators should be able to control which traffic is routed over WLAN and which one is kept on 3G. For example, some IP flows (e.g., related to VoIP or other operators' services) can be maintained over 3G to leverage its QoS capabilities, while IP flows related to "best-effort" Internet traffic can be offloaded to WLAN.

[3] 3G/Wi-Fi Seamless Offload Pathway

A simple mechanism to offload data traffic from 3G to Wi-Fi is already available today using an application-based approach to switch beween both radios.

Any network supporting 3GPP Release 8 can provide 3G/Wi-Fi mobility. The IP Flow Mobility, which provides the capability to move selected traffic, will be available in Release10.

However, this solution has limitations, and in order to improve the overall capabilities of such an approach, 3GPP has introduced a Wi-Fi mobility framework in Release 8 to enable seamless handover between 3G and WLAN.

Looking forward, to futher improve the flexiblity of the offlload solution, 3GPP has defined a work item in Release 10 to introduce IP Flow Mobility and enable seamless movement of selected IP traffic while supporting simultaneous 3G and Wi-Fi accesses. The offload mechanisms are based on operator-controlled configurations and traffic characteristics. Figure 1 illustrates the pathway toward 3G/Wi-Fi Seamless Offload.

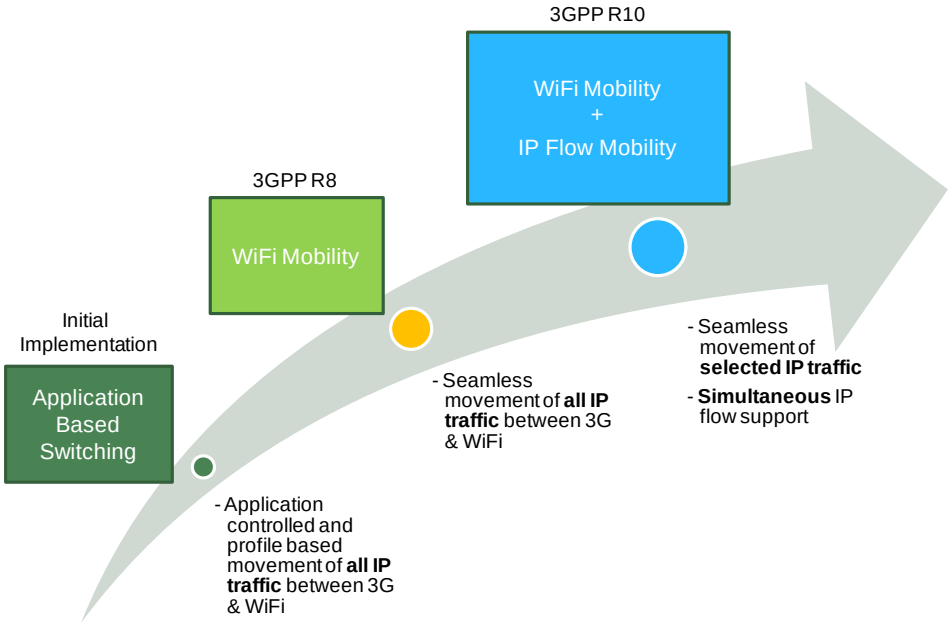

Figure 1: 3G/Wi-Fi Seamless Offload pathway

[4] Application-Based Switching

Application layer solution provides suboptimal interim solution for network connectivity.

An application-based solution (see Figure 2) is a simple mechanism to offload data traffic from 3G to Wi-Fi and is available today. However, this approach does not provide IP preservation and relies on the application to "survive" the IP address change or re-establish the connection after the switch to WLAN.

Depending on the application design, the WLAN connection is established without any action required from the user. Most applications however, break or provide a negative user experience (e.g., VPN connection, video streaming with low buffering, HTTPS connections).

The application-based solution does not provide a compelling user experience in most cases, since control of mobility and user experience are left to application developers.

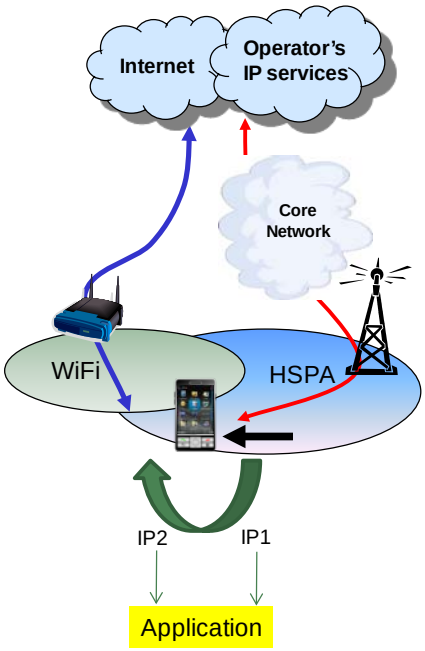

Figure 2: Application-based switching

[5] Wi-Fi Mobility

3GPP Release 8 introduces a client-server based protocol, Dual Stack Mobile IP (DSMIP), to enable seamless handover between 3G and Wi-Fi. DSMIP is a mobility protocol specified in IETF that provides IP address preservation for IPv4 and IPv6 sessions, allowing the user to roam independently in IPv4 and IPv6 accesses.

DSMIP allows mobility across networks while maintaining IP address continuity.

The solution does not require any support from WLAN accesses. If the cellular radio access network supports a Home Agent (HA), the only new requirement is that the UE (i.e., client) and the Home Agent (i.e., server) are dual-stack capable. Applications and accesses can be either IPv4 or IPv6 depending on the deployment models of the operators. Therefore, the changes required are only to UE and GGSN/PDN-GW. The Home Agent (HA) can be implemented as a functionality in the GGSN/PDN-GW or standalone box.

The HA is the anchor that binds the permanent identifier of the node (i.e., Home Address or HoA) with the local address based on the node's location (i.e., Care-of-Address or CoA). The exposed IP address accessible by the application remains the same (see Figure 3).

DSMIP can be used over trusted and/or untrusted non-3GPP Access (e.g., Wi-Fi) and/or 3GPP access (e.g., HSPA, LTE). Wi-Fi mobility in 3GPP R8 can be implemented either using DSMIP over H1 or S2c interface. The H1 interface is compatible with pre-R8 GGSN and PDG, and the S2c interface is part of the EPS/LTE architecture.

DSMIP can be used over trusted and/or untrusted non-3GPP Access (e.g. Wi-Fi) and/or 3GPP access (e.g. HSPA, LTE)

DSMIP provides a better user experience compared to application-based switching, since it preserves the IP address whenever the network is changed. Furhermore, DSMIP is easily portable to multiple devices since it does not depend on the application.

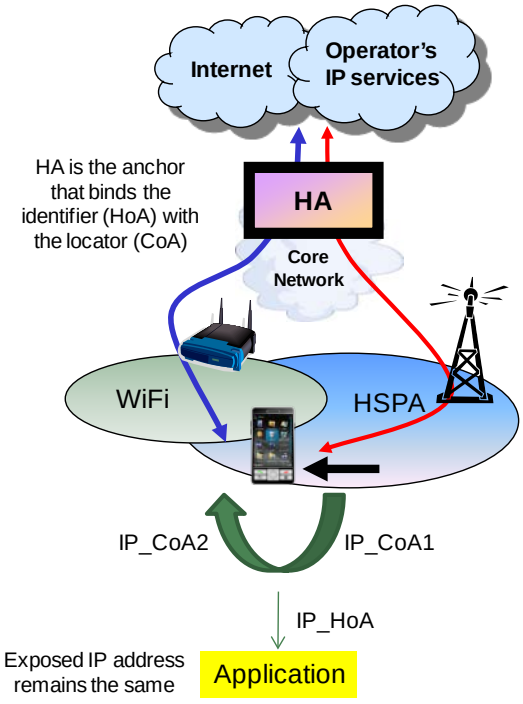

Figure 3: DSMIP-based Wi-Fi mobility

[6] 3G/Wi-Fi Seamless Offload

6.1 Overview

3G/Wi-Fi Seamless Offload is a further enhancement to the solution based on Dual Stack Mobile IP (DSMIP) that enables seamless handover between 3G and Wi-Fi. It also provides the possibility to move selected IP traffic (i.e., HTTP, Video, VoIP, etc) while supporting simultaneous 3G and Wi-Fi access.

The main components of the solution are DSMIP with extensions for seamless IP Flow Mobility, Access Network Discovery and Selection Function (ANDSF) extensions for providing operator control, and PCC enhancements for QoS.

6.2 IP Flow Mobility

IP Flow Mobility and multi access provides selective offload.

3G/Wi-Fi mobility using DSMIP as per 3GPP Release 8 provides a solution for seamless WLAN offload where all traffic is offloaded to the WLAN. However, it may be desired that in some scenarios only some traffic is moved to the WLAN while other IP flows are maintained over the 3G access. This requires some DSMIPv6 extensions to allow the registration of multiple addresses simultaneously. These protocol extensions, known as IP Flow Mobility, are part of 3GPP Release 10 and introduce the capability to move selective IP traffic – a new dimension in flexibility.

More specifically, the extensions defined for DSMIPv6 have the capability to register multiple local addresses (i.e., CoAs) to a single permanent address (i.e., HoA), and also the capability to bind different IP flows (i.e., HTTP, Video, VoIP, etc) to different CoA or directly to HoA (see Figure 4).

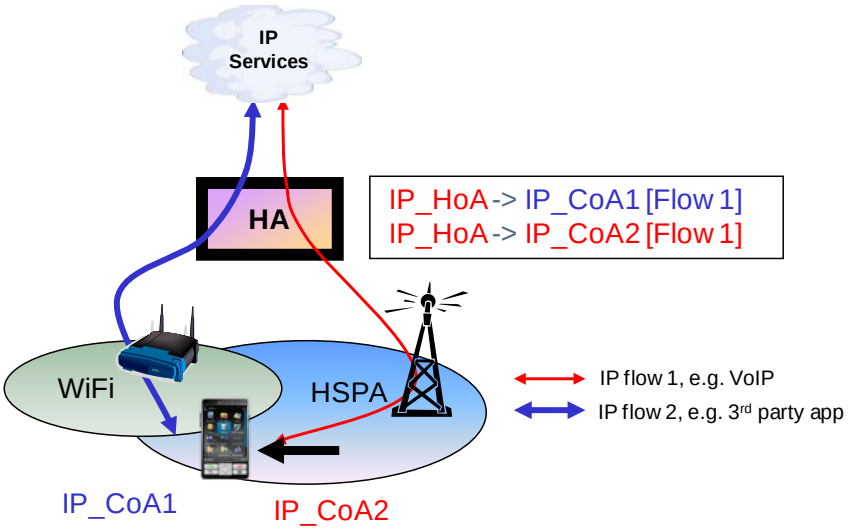

Figure 4: IP flow mobility

Like all IP address preservation mechanisms, IP Flow Mobility requires the traffic to be anchored in a central gateway (e.g., HA). Therefore, the

traffic has to pass through the HA whenever mobility and session continuity are required. In order to use network resources in the most efficient way, the proper approach is having a mix of traffic anchored at the HA for mobility purpose (i.e., VPN, Video) and some traffic completely offloaded to WLAN without traversing the HA (i.e., HTTP).

6.3 Policies

Wi-Fi discovery and selection can be imposed as per operators' policy via ANDSF inter-system mobility policies.

3GPP Release 8 has specified the Access Network Discovery and Selection Function (ANDSF) framework through which the operator can provide inter-system mobility policies. The framework is based on a direct communication between the handset and an Open Mobile Alliance (OMA) Device Management (DM) (OMA-DM) server (see Figure 5). The inter-system mobility policies introduced in Release 8 are a preference list of the access that the UE should use in a given location and time.

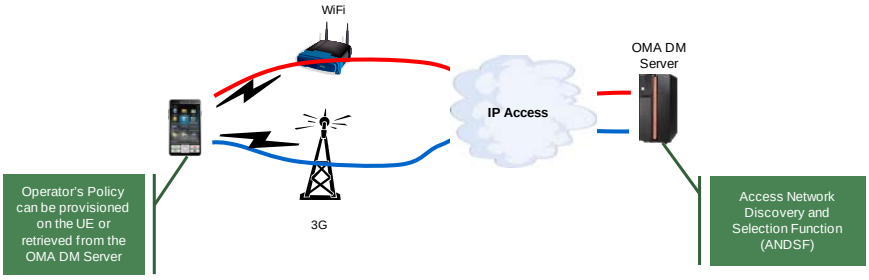

Figure 5: ANDSF framework

These policies can be easily extended to provide policies for IP Flow Mobility. The same structure of policies can be used introducing a validity condition for each policy that indicates for which type of traffic the policy is to be used. For instance, the operator can provide a policy, which indicates that WLAN should be used for all traffic to port 80, but a 3GPP access should be used for a given media (e.g., audio).

6.4 Policy and Charging Control (PCC) Extensions

The 3G/Wi-Fi Seamless Offload solution does not require any PCC support (i.e., it can be deployed also without PCC). When IP Flow Mobility is used and PCC is deployed, the PCC architecture is enhanced to handle multiple simultaneous access connections for a single IP session.

[7] Network Discovery and Selection

In dual radio scenarios, such as WLAN and cellular, the two access networks are not “aware” of each other and one access network cannot control the device protocol state in the other access network. Also, the WLAN is not a “controlled” access network and works opportunistically in unlicensed spectrum; therefore the only element in the network that is known is when a WLAN is available, the radio quality and the performance that can be achieved through that WLAN is available only to the device. Hence, the device is best positioned to decide the connectivity options.

The device is best positioned to decide about connectivity options.

In this context, network discovery and selection procedures can be performed by a connection manager in the device. This kind of connectivity management is out of the scope of 3GPP and is up to the vendors to provide a solution. More intelligent connection managers (see Figure 6) can search and prioritize the best available links based on pre-defined requirements such as QoS, bandwidth, latency, jitter, power consumption, operator policies, etc.

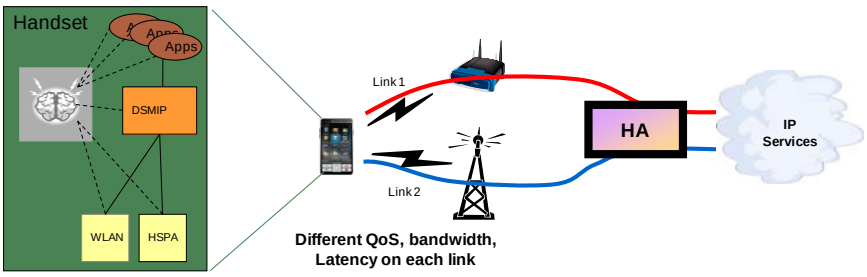

Figure 6: Intelligent discovery and selection

[8] Seamless WLAN Authentication

Seamless authentication increases the value in data session continuity from 3G to WLAN. From a user experience perspective, it is important to have authentication mechanisms that do not require user intervention when switching from one access to another.

A pre-configured Wi-Fi Protected Access (WPA) key provides automatic WLAN authentication for both home and office hotspots. A digital certificate can be used for enterprise hotspots. The user has to enter the

User intervention for authentication decreases the value in seamless data session continuity from 3G to WLAN.

WPA key just once, and then the connection manager or Wi-Fi client shall remember the AP and respective keys.

For operator owned hotspots, 3GPP Release 7 provides a solution using Extensible Authentication Protocol (EAP)-AKA and EAP-SIM methods for key distribution to the WLAN access network, which facilitate seamless handover between the various accesses.

[9] 3GPP2 Applicability

The DSMIP framework used in the 3G/Wi-Fi Seamless Offload solution, which enables seamless handover between 3G and Wi-Fi, can also be applied to 3GPP2 networks without any changes to the packet data network architecture. It is important to note that the mobile IP architecture is already part of the 3GPP2 specifications. Furthermore, the ANDSF framework and IP Flow Mobility policies can also be applied to a 3GPP2 system. However, the IP Flow Mobility extensions of Release 10 need to be incorporated in the specifications to allow for selective IP traffic movement.

[10] Conclusion

Mobile data traffic consumption is increasing exponentially. Since WLAN is widely available at home and through various hotspots, and is also in a number of 3G devices, it offers the potential to become a seamless extension of 3G.

The 3G/Wi-Fi Seamless Offload solution, which is based on Dual Stack Mobile IP (DSMIP), enables seamless handover between 3G and Wi-Fi, and also provides the possibility to move selected IP traffic while supporting simultaneous 3G and Wi-Fi access.

The 3G/Wi-Fi Seamless Offload solution not only offers seamless offload of best-effort data from 3G, but also offers an operator controlled and service-based selection of 3G or Wi-Fi. Furthermore, the solution offers simple and standardized implementation to operators that want to minimize data cost and better utilize their assets.