Mobile Offload Architectures and Fixed Mobile Convergence

BRKSPM-5327

www.ciscolivevirtual.com
Agenda

1. Mobile Data—Drivers for Change
2. Addressing the Economics
3. Access Offload Requirements
4. SP WiFi Architectures
5. Traffic Optimisation
6. Summary
Mobile Networks: Drivers for Change

Growth in Mobile Data: x18 over 5 years (CY11-16)

1. 180% increase in signalling traffic due to smartphones
2. Lack of spectrum and inability to rapidly increase # cell sites
3. 70% of mobile traffic to be video by 2016
4. A shift from outdoor consumption to indoor

- Economics of indoor offload and small cell systems
- WiFi already used to support >30% of US smartphone usage
Drivers for Change: Scaling Supply Delivering 26-Fold Increase in Supply

Source: Agilent
Drivers for Change: Wi-Fi Availability & Usage Pattern

- Majority consumption occurs indoors (home, office, venues)
- Wi-Fi coverage readily available at most locations
- According to Millennial Media, 39% of the impressions comes from Smartphones connected over Wi-Fi networks (Nov/11) – 4% rise in 5 months
Evolution Toward Heterogeneous Networks

Today

HNB GW

Femto

BYO WiFi

Tomorrow

Small Cell GW

HNB GW

Enterprise HNB GW

Enterprise Femto

Femto

SP WiFi

Metro GW

Metro Wireless

BBU/RRH

RNC

Cisco Public
Delivering Converged Control

Packet Core

- Radio Network Controller
- Macro Coverage Cell
- UE

- Femto Controller
- Licensed Femto Cell

- WiFi Controller
- Trusted Unlicensed SP WiFi

- ePDG TTG
- Un-Trusted WiFi AP

HS2.0 IP Persistence
I-WLAN IPSec Access
Market Summary

- Mobile Broadband demand growth means only a matter of time before carriers will need to start to aggressively deploying more cells.
- Site/zoning limitations may restrict ability to deploy many more conventional macro cells in capacity situations.
- As consumption rises, it becomes increasingly cost effective to offload onto indoor broadband networks.
- Status quo operation will not be an option if supply side restrictions are to be avoided.
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## Breakdown in Cost of Production

Source: ABI/Cisco May 2011

<table>
<thead>
<tr>
<th>Single Cell $ per GB</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Site CapEx (1 Carrier, 3 Sector)</td>
<td>14%</td>
</tr>
<tr>
<td>Cell Site OpEx</td>
<td>45%</td>
</tr>
<tr>
<td>IP RAN CapEx</td>
<td>18%</td>
</tr>
<tr>
<td>IP RAN OpEx</td>
<td>18%</td>
</tr>
<tr>
<td>RNC CapEx</td>
<td>1%</td>
</tr>
<tr>
<td>MPC CapEx</td>
<td>2%</td>
</tr>
<tr>
<td>Core OpEx</td>
<td>2%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>
### Three Parallel Tracks for Macro Access Offload

<table>
<thead>
<tr>
<th>Metro/Hotspot Access</th>
<th>Residential Access</th>
<th>Office Based</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metro WiFi deployments driven by spectrally challenged operators</td>
<td>Peak consumption occurs 10pm/indoors drives compelling macro offload economics and MNO offload targets</td>
<td>Guest WiFi evolution facilitates ease of use of WiFi offload using enterprise infrastructure</td>
</tr>
<tr>
<td>Stadium traffic set to dwarf any licensed capacity installed by MNOs</td>
<td>MVNO economics motivating MVNOs to accelerate residential macro offload deployments</td>
<td>Enterprise femto provides in-building coverage and enterprise capacity offload from macro cell</td>
</tr>
<tr>
<td>Hotspot becoming an integral part of MNO offload strategy</td>
<td>Community deployments enhanced with seamless mobility allows increased macro offload in dense urban environments</td>
<td>Enterprise GWs allow optimised access from enterprise employees to business services (LAN access, UC&amp;C, etc)</td>
</tr>
<tr>
<td>Metro WiFi operators leasing real estate/power/backhaul to MNOs for Pico deployment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Macro-Cellular Offload (Cell Site, Backhaul and Controller)
Modelling Economics of Smart Mobility

- **Macro Networks Mobile Internet Economics** – significant incremental cost of production
  - Ranges from ~$2/GB (3 carrier config) to ~$6/GB (1 carrier config)

- **Indoor offload solutions** deliver very low incremental cost of production, similar to fixed Internet economics

- **As consumption rises**, becomes more cost effective to offload traffic:
  - Compared with a 1-carrier macro cell, femto delivers improved economics for users with >750 MB/mo consumption
  - Compared with a 3-carrier macro cell, SP WiFi delivers improved economics for users with >500 MB/mo consumption

Source: ABI/Cisco Cost of Production Analysis, assuming CPE offered without cost to consumer and depreciated over 3 years
Modelling Economics of macro/micro/pico

- Holistic model of an entire mobile SP (or MVNO)
- Initial focus on cost optimisation – current burning platform

Non-uniform demand across users

Impact of indoor versus outdoor demand

Non-uniform demand across geography

Wireless Economic Model

Multiple and overlapping technology choices

Multiple types of offload

Source: Cisco IBSG Research & Economics Practice, 2011
Example Model Assumptions: Large Western European Market

### Market Data

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>60M</td>
</tr>
<tr>
<td>3/4G covered area</td>
<td>215 km²</td>
</tr>
<tr>
<td>3G cell sites</td>
<td>15,000</td>
</tr>
<tr>
<td>Spectrum</td>
<td>3x5MHz</td>
</tr>
</tbody>
</table>

### Metro offload Assumptions

<table>
<thead>
<tr>
<th>Assumption</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>AP radius</td>
<td>50m</td>
</tr>
<tr>
<td>One-off cost/AP</td>
<td>$2950</td>
</tr>
<tr>
<td>Recurring cost/AP</td>
<td>$1740</td>
</tr>
<tr>
<td>Capacity/AP</td>
<td>5Mbps</td>
</tr>
</tbody>
</table>

### Traffic Distribution

<table>
<thead>
<tr>
<th>% of network wide traffic</th>
<th>% of all cell sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Metro Usage Distribution

<table>
<thead>
<tr>
<th>% of sector wide traffic</th>
<th>% of sector area</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>80%</td>
<td>80%</td>
</tr>
<tr>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Cisco IBSG Research & Economics Practice, 2011
Metro Small Cell: Progressive Deployment

- Macro cell splitting challenged to economically deliver increase in supply.
- Operators will need to switch to microcell deployment to deliver more cost effective capacity.
- Metro Small Cell is justified in areas of high traffic density – model estimates $0.5bn savings compared to macro cell split.
- Metro roll out is progressive as traffic grows, and by year 5, there are 4 mesh access points for every 3/4G macro-site.

Source: Cisco IBSG Research & Economics Practice, 2011

Investment ($B)

- **Macro Cell Split**
- **Macro + Micro Deployment**
- **Macro + Small Cell Deployment**

Macro Cell Split
Macro + Micro Deployment
Macro + Small Cell Deployment
LTE – a saviour or a stop-gap?

Both LTE and Wi-Fi contribute to reducing SP network spend as traffic grows.

Source: Cisco IBSG Research & Economics Practice, 2011
Small Cell Segmentation

- Femto network providing indoor coverage and capacity (residential, SMB, …)
- WiFi offload of indoor capacity – venue, stadium, hotspot, office, residential
- Real Estate driven Total Cost of Ownership
- Multi-vendor macro integration requirements. Third party integrated SON.
- Dense metro WiFi coverage network (leveraging aerial plant) focused on churn reduction
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Macro Radio Access Offload

- Future Networks supporting the Mobile Internet will need to seamlessly integrate a lot more smaller cells
- Shifting from $10^4$ cells to $10^6$ cells will require a change of mindset and management tools
- Key decisions that need to be considered:
  - Whether to use unlicensed, licensed technology or both?
    - Unlicensed already being deployed for BYO offload
    - Unlicensed better suited to very high density deployments
  - If using unlicensed, what does the architecture look like?
Femto Growing into Metro Offload?

- Femto Forum defining “Open Femto” to support public deployments
- RAN vendors enhancing RNC to enable macro-to-femto handover
- Release 10 specifications define interference co-ordination capability between LTE femto/pico and macro
- But...
  - Deployments of multi-vendor WCDMA metro femto preferably require clear frequency or domain management integration
  - Dense metro deployments likely to require wireless (mesh) backhaul e.g., 1 Route AP for 4 Mesh APs, with broadband connectivity every km.
- .... so what about WiFi?
Examples of Different SP WiFi Standardisations Activities

No Single Forum Driving SP WiFi

  
  Web based (UAM) and 802.1X based access

- 2003: GSMA IR.61 WLAN Roaming Guidelines
  
  AAA and Transferred accounting procedures

- 2004: IEEE 802.11i
  
  802.1X/EAP based authentication and secure WiFi access network

- 2004: 3GPP Release 6 “I-WLAN”
  
  802.1X based access network and IPSec for accessing home services

- 2006: IETF CAPWAP Working Group
  
  First Internet draft of CAPWAP protocol

- 2008: 3GPP Release 8 “Trusted non-3GPP”
  
  Common core network and peer trust agreement for integrating non-3GPP access networks

- 2010: Wireless Broadband Alliance: WiSPR 2.0
  
  EAP support over non 802.1X

- 2010: 3GPP Release 10: “IP Flow Mobility and seamless WLAN offload”
  
  Simultaneously connection to cellular and WiFi with policy based access via WLAN

- 2010: Cablelabs WiFi Roaming Architecture
  
  AAA support for HTTPS and EAP

- 2010: Cablelabs WiFi Management Object
  
  TR-069/SNMP SP WiFi Configuration, Performance and Fault management

- 2011: WFA Next Gen Hotspot
  
  Standardised delivery of newly created credentials to Connection Manager (HS2.0)

- 2011: IEEE 802.11v
  
  Stations can be aware of network conditions, including interference and to load balance clients between APs
Target Architecture

- Build a converged approach that allows SP WiFi to be treated as “trusted non-3GPP access”
- 3GPP has defined an architecture based on PMIPv6 for “trusted non-3GPP” support
- SP WiFi with 802.1X/EAP meets all requirements to be considered “trusted non-3GPP”
- IETF based, S2a profile already specified by 3GPP
  - Delivers multi-vendor interoperability
- SP WiFi Standardisation effort limited:
  - Need to define an Implementation Agreement on how to populate defined attributes
  - Simple enhancements defined to be able to support web based authentication (out of scope of 3GPP)
- Hotspot 2.0 specifying L2 authentication procedures, Network-Discovery/Selection procedures and credential management
Cisco SP WiFi Unified Architecture

Delivering Converged Policy and Wholesale Services

Packet Core

Roaming/Transient Anchor

Radio Network Controller

NB Base Station

Macro Cellular Today

Security Gateway

Home NB

Residential Cellular Today

Core Network Tunnelling: GTP Roaming and LMA Integration

SP WiFi Wholesale/Roaming Platform

Wireless LAN Controller

MME

ENB Base Station

Macro Cellular Tomorrow
### Controller-based vs Controller-less

#### System Requirements

<table>
<thead>
<tr>
<th>Management Plane</th>
<th>Residential (single AP)</th>
<th>Hotspot (single AP)</th>
<th>Hotzone (multi AP)</th>
<th>Metrozone (High Density)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-real time/reactive Remote management</td>
<td>Real time/Proactive Remote management, Management GUI</td>
<td>Centralised Policy, Seamless (Fast) Mobility, Rich User Analytics</td>
<td></td>
</tr>
<tr>
<td>Control Plane</td>
<td>Autonomous Control Plane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>User/Data Plane</td>
<td>Centralised Policy Enforcement</td>
<td>Scalable Tunneled Data Plane Centralised Policy Enforcement Decoupling of Data and Control Plane</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF Control</td>
<td>Autonomous RF parameter setting</td>
<td>Real time/proactive RF management</td>
<td>Co-ordinated RF Optimisation, Coverage Hole Detection/Mitigation, Real time air quality visibility</td>
<td></td>
</tr>
</tbody>
</table>
Supporting a Phased Evolution of Functionality

Automate Authentication
- MAC-TAL
- Username/Password
- AAA Roaming
- EAP-SIM/AKA

User-Plane Integration
- No Integration
- PMIPv6/GTP Integration
- Static Offload Rules
- Dynamic Offload

Client Integration
- No Client
- I-WLAN
- HS2.0
- Mobile IP
Evolving Security Requirements for SP WiFi Transitioning to Trusted Non-3GPP

**Today**

- Web Authentication, no over the air security, open to simple MAC-spoofing attacks
- MPC/EPC integration requires I-WLAN IPSec overlay
- Charging records can be repudiated
- WiFi Security is largely an enterprise concern

**Tomorrow**

- 802.1X/EAP based authentication and over the air encryption
- Clientless MPC/EPC integration with seamless access to operator’s service LAN environment
- Non-repudiation requirements
- WiFi Security moving centre stage for Service Providers

• “Now, it may be considered by operators that the security strength and ease of use of WiFi is as acceptable as 3G/LTE security. For example, the operator controlled hotspot with 802.11i could be treated as the trusted Non-3GPP Access.” Source: 3GPP 23.852
Smooth Evolution from legacy WiFi solutions
Leveraging 10 years of SP WiFi Solutions

- Cisco has been delivering SP WiFi systems for almost a decade
  Autonomous Cisco Hotspots with Access Zone Routers (AZR) – 2002
  Residential SP WiFi Architectures based on L2TP – 2004
  Metro mobility with Cisco Unified Wireless Network (CUWN) - 2006

- Committed to delivering core capabilities which enable smooth migration according to evolving customer requirements, e.g.,
  1. WiFi Wholesaler who has significant installed base of Autonomous/AZR and CUWN based solutions plans to deliver GTP wholesale service using ASR 5K
  2. Existing SP WiFi customers requiring integration of legacy Cisco WiFi solution into 3rd party LMA/P-GW
  3. New MNO SP WiFi customer require integration of Cisco SP WiFi subscriber control into existing Gx/Gy/Gz charging and policy environment (parental controls, etc)
Client Requirements

- The fundamental difference between SP WiFi and femto is ability to enhance user experience through support of additional client functionality.

- Diverse set of requirements/functions
  - Discovery
  - Automated Log-on
  - Security (trusted/untrusted 802.11, trusted/untrusted roaming partner)
  - Connection Management
  - Flow Policy
  - QoS
Client-Based: Heterogeneous or Homogeneous?

Heterogeneous, Supports Various Approaches to Client Evolution

- OS Connection Manager
  - Enhanced CM/WISPr 1.0
    - HS 2.0 Cred. Management
    - EAP/802.1X
      - IPSec/IKEv2
        - CMIP/DSMIPv6
          - ANDSF + 802.11r
            - VoIMS
          - IP Flow Mobility/Split Tunnel
            - Optimised Data Offload
          - GAN + IPSec+ EAP

Homogeneous One Size Approach
Leveraging Client Functionality Whenever Available

On-Net Access
- 802.11i delivers trusted non-3GPP access with EAP-based trust indication
- PMIPv6 delivering mobility to simple IP clients
- HS2.0: auto login, service advertisement, and online sign-up

Off-Net Access
- WISPR 1.0 Automated web credential management
- I-WLAN allows to tunnel over 3rd party untrusted network to access home operator services

Inter Technology Handover
- DSMIPv6 and DSMIPv6/IPSec for seamless offload
- IP Flow Mobility for policy based offload
Converged Subscriber Policy Enforcement

All Client-less and Client-based configurations supported

Multiple Applications Simultaneously Running on Session-Centric Operating System

Converged, Per subscriber Policy, Charging and Billing Systems

<table>
<thead>
<tr>
<th>Devices</th>
<th>Trusted Wi-Fi</th>
<th>IP Core</th>
<th>Mobile Packet Core</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clientless – IPSG (IP)</td>
<td>VPN</td>
<td>Un Tunneled User Data (IP)</td>
<td>GTP (Gn)</td>
</tr>
<tr>
<td>Clientless MAG (PMIPv6)</td>
<td>MAG</td>
<td>Per User PMIPv6 Tunnel</td>
<td>TTG</td>
</tr>
<tr>
<td>Clientless eWAG (GTPv1)</td>
<td>eWAG</td>
<td>Per User GTP Tunnel</td>
<td></td>
</tr>
<tr>
<td>Clientless 3GPP2</td>
<td>HSGW</td>
<td>Per User PMIPv6 Tunnel</td>
<td></td>
</tr>
<tr>
<td>Clientless 3GPP</td>
<td>SGSN</td>
<td>Per User GTP Tunnel</td>
<td></td>
</tr>
<tr>
<td>Secure Client based iWLAN</td>
<td>3G Cellular</td>
<td>Per User IPSec Tunnel</td>
<td></td>
</tr>
</tbody>
</table>

Untrusted Wi-Fi

3G Cellular

Per User PMIPv6 Tunnel

Per User GTP Tunnel

VPN

MAG

eWAG

HSGW

SGSN
Hotspot 2.0 Vision
Cellular Mobility Experience on Wi-Fi

GSM

Turn on phone and get secure cellular connectivity.

Hotspot 2.0

Turn on device and get secure Wi-Fi connectivity.

Automatic. Secure. SIM/AKA Based.
HotSpot 2.0

- Make WiFi as easy to use as Cellular
- Solve the WiFi Roaming problem
  - Based on 802.11u standards
- Solve the WiFi security problem
  - Based on 802.11i
  - Based on EAP (EAP-SIM/EAP-TLS/EAP-FAST)
- Solve the non-SIM credential management problem
  - Standardized delivery of newly created credentials to Connection Manager
- Achieve interoperability through WFA Certification program
- Announced at MWC 2011
Next Generation Hotspot / Hotpsot 2.0
Discover, Roam, Authenticate, Monetize

1. PreAssocc
2. PreAuthentication
3. Auto SIM credentials
4. Encrypted Wi-Fi Link

Mobile “concierge” service

RELIABLE
Carrier class solution

SEAMLESS
Simplified network discovery and selection optimizes offload

SECURE
SIM-based authentication techniques over encrypted Wi-Fi

MONETIZE
Location-based and value-added services

ROAMING
Seamless WiFi Roaming via standardized authentication and settlement
## NGH Technology Enablers

<table>
<thead>
<tr>
<th>Authentication and Roaming</th>
<th>Hotspot (Today)</th>
<th>NGH (HS2.0 Spec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Discovery and Selection</td>
<td>SSID</td>
<td>802.11u</td>
</tr>
<tr>
<td>L2 Authentication</td>
<td>None</td>
<td>802.11x</td>
</tr>
<tr>
<td>Layer 2 Air Encryption</td>
<td>None</td>
<td>802.11i</td>
</tr>
<tr>
<td>L3 Authentication</td>
<td>WebAuth WISPr</td>
<td>EAP-SIM, AKA, TLS, TTLS</td>
</tr>
<tr>
<td>Hotspot Network</td>
<td>Untrusted</td>
<td>Trusted</td>
</tr>
<tr>
<td>IPR</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Interoperable</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
HS 2.0 Information for network selection

Roaming related (ANQP) Feature

- Venue Info
- HESSID
- Roaming Consortium list
- Realm name list
- 3GPP Cellular network information
- Domain name list
- Operating Class Indication
- Operator Friendly name

Domestic network connection feature

- HS 2.0 Network Indicator
- WPA2-Enterprise
- BSS Load (Channel Util.%)
- Multicast Indicator
- WAN Metrics (backhaul link info, including load)
- Network Port Availability
- Proxy ARP at AP
- P2P Disable at AP
HotSpot 2.0/NGH System Component

**Handset**

- **Driver (11u)**
- **Chipset (Broadcom, Atheros, TI, etc..)**
- **ANQP**
- **802.1x (EAP)**

**AP Infra**

- **AP**
- **CAPWAP**
- **WLC**
- **NAS Client**

**AAA Server/Proxy**

- **Subscriber DB/HLR**
- **AAA Server**
- **Roaming Partner**
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Key SP Wi-Fi Requirements

- Seamless end-user experience
  - Intra-network and inter-network roaming/mobility

- Carrier-grade operation
  - Wireless performance
  - Interference mitigation
  - Reliable coverage
  - Robust capacity and throughput
  - Control of security, management, mobility, authentication, billing, policy
  - Standards-based

- End-to-end scalability
  - Designed to support millions of users and exponential traffic growth
Service Provider Wi-Fi Solution
Four Pillars

Key SP Wi-Fi Requirements

Mobility, Carrier-Grade, Scalability, Security

Intelligent Radio
Unified Architecture
Seamless Experience
Converged Core

Cisco Solution Pillars
Service Provider Wi-Fi Solution

Four Pillars

**Intelligent Radio**
- Complete portfolio of indoor and outdoor 802.11n APs
- CleanAir delivers integrated spectrum intelligence
- ClientLink with RRM and beamforming
- Real time analytics available to venue owners

**Unified Architecture**
- Fast and real time scalability and handoff management
- Single security and inter-operability point
- System-wide management and monitoring for indoor and outdoor networks
- Residential, Hotspot, Hotzone, Metrozone

**Seamless Experience**
- Effortless authentication and roaming
- Open or secure access with expanded hotspot eco-system
- Ready for migration to Next Generation Hotspot with simple software upgrade

**Converged Core**
- Standardised centralised subscriber access control
- Per subscriber policy control (e.g. tiered services and parental controls)
- Standardised policy and charging environment

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Intelligent Radio
Not All Access Points Are the Same

Best in class Radio Resource Management coupled with beamforming to deliver focused power to clients

**Improves Network Throughput and Coverage**

Sophisticated spectrum Intelligence to monitor the airwaves; detect, locate and classify interference; alert Ops; and reconfigure the network to avoid

**Improves Network Reliability**

Optimised RF utilisation by moving 5 GHz capable client out of the congested 2.4 GHz channels

**Improves Network Throughput**

Extends reliable multicast into the wireless network by converting multicast to unicast at the AP

**Quality Video over WLAN**
Service Provider WiFi: CleanAir SON
Bringing rich spectrum intelligence to 802.11 Networks

Detect and Classify
Locate
Mitigate Interference

Cisco CleanAir
Customer results from live deployment.
2.4 GHz outdoor deployment with >100 interfering public and private access points.
Delivering >8 times performance of customer’s 3G network.
SP WiFi Architecture: Addressing the deployment and offload issues

MNO

FNO

MSO

3G/4G Mobile Packet Core

Fixed BB Infra.

Converged Operator
E2E SP WiFi User Plane Architecture:
# Four Phase 1 Deployment Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Name</th>
<th>Access Points</th>
<th>Controller</th>
<th>Access Aggregation</th>
<th>Subscriber Control</th>
<th>Policy Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>ServiceMesh Centrally Switched</td>
<td>Indoor/Outdoor APs</td>
<td>5508/ WISM2</td>
<td>L3</td>
<td>1K ISG</td>
<td>Broadhop</td>
</tr>
<tr>
<td>1.2</td>
<td>ServiceMesh locally Switched</td>
<td>Indoor APs</td>
<td>5508/ 7500/ WISM2</td>
<td>AZR &amp; 1K</td>
<td>1K ISG</td>
<td>Broadhop</td>
</tr>
<tr>
<td>1.3</td>
<td>EPC Integration (EAP/802.1x only)</td>
<td>Indoor/Outdoor APs</td>
<td>5508/ WISM2</td>
<td>L3 + 1K MAG</td>
<td>5K P-GW</td>
<td>Incumbent</td>
</tr>
<tr>
<td>1.4</td>
<td>IPSG Integration</td>
<td>Indoor/Outdoor APs</td>
<td>5508/ WISM2</td>
<td>L3</td>
<td>5K IPSG</td>
<td>Broadhop</td>
</tr>
</tbody>
</table>
Deployment 1.3: EPC Integration Call Flow Overview

Overview

CiscoAR AAA

ASR5K PGW / LMA

STP

HLR

Clientless AP WLC

802.1X EAP Negotiation

EAP Authentication / Authorisation

DHCP Discover

DHCP Relay

DHCP Offer (IP Address, Mask, GW, DNS)

DHCP Request / Ack

IP Traffic

Radius.Req

Radius.Accep

User Record Cached

ASR1K MAG

PMIPv6 Trigger

User Authorised LMA/NAI Downloaded

Gx/Gy: CCR

Gx/Gy: CCA

Binding on LMA for Client

PBU

PBA

Internet

Policy & Charging
Deployment 1.4: PCC Integration Call Flow Overview

Overview

CiscoAR AAA

Radius.Req → Radius.Req → MAP
Radius.Accep → Radius.Accep → MAP

STP
HLR

ITP

AP
WLC

Clientless

802.1X
EAP Negotiation
EAP Authentication / Authorisation

DHCP Discover
DHCP Relay
DHCP Offer (IP Address, Mask, GW, DNS)
DHCP Request / Ack

802.1X
EAP Negotiation

User Record Cached

L3 IP PoA

ASR5K IPSG

Policy & Charging

Gx/Gy: CCR
Gx/Gy: CCA

Build State for User

Internet

Proxy adds User Info


IP Traffic


Radius.Accep

DHCP Offer (IP Address, Mask, GW, DNS)
DHCP Request / Ack

EAP Negotiation
EAP Authentication / Authorisation

ITP

Radius.Accep

Radius.Accep
Standardised Web Based Authentication?

- Native 3GPP PCEF (e.g., LMA) assumes user has been L2 authenticated prior to access
  
  For web auth, user requires IP address allocation prior to authentication

- If PCEF is responsible for IP address allocation, this poses a problem
  
  PCEF is responsible for generating CDRs which will be opened before user’s authenticity has been confirmed

- Need to realise a two stage approach if standardised PCEF components are to be used
  
  Stage 1: If MAC address is unknown, need to use captive portal to allow user to enter credentials and then associate MAC address with authenticated identity

  Stage 2: After user has authenticated, trigger re-establishment of session when MAC address can be associated with a valid user identity and correct CDRs generated
Agenda

1. Mobile Data—Drivers for Change
2. Addressing the Economics
3. Access Offload Requirements
4. SP WiFi Architectures
5. Traffic Optimisation
6. Summary
Optimising the Architectural Hierarchy

<table>
<thead>
<tr>
<th>National</th>
<th>GGSN</th>
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<tbody>
<tr>
<td>Regional</td>
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<tr>
<td>Market</td>
<td>RNC</td>
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<tr>
<td></td>
<td>HNB GW</td>
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<td>Node B</td>
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<td>Local IP Access Gateway</td>
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<tr>
<td>Premise</td>
<td>HNB</td>
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Selective IP Traffic Offload
Local IP Access
Breakdown in Cost of Production
Cisco/ABI May 2011

<table>
<thead>
<tr>
<th>Single Cell $ per GB</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Cell Site CapEx (1 Carrier, 3 Sector)</td>
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<tr>
<td>Cell Site OpEx</td>
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<tr>
<td>IP RAN CapEx</td>
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<tr>
<td>IP RAN OpEx</td>
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<tr>
<td>RNC CapEx</td>
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<tr>
<td>MPC CapEx</td>
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<tr>
<td>Core OpEx</td>
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</tr>
<tr>
<td>Total</td>
<td>100%</td>
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Core Distribution/Offload Unlikely to Be Driven Solely from an Economics Perspective!
Can Offload/Distribution Improve the Average User Experience?

- Use Sprint Looking Glass tool to estimate Round Trip Time improvements from GW distribution

Looking Glass allows to record inter POP Round Trip Time between 25 locations

- Compare case of fully distributed GW at 25 POPs with centralised GW at 3 POPs

Centralised GW in Anaheim, Chicago and Pennsauken increases the average RTT across the network by 13 ms

<table>
<thead>
<tr>
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<th>Anaheim CA</th>
<th>Chicago IL</th>
<th>Pennsauken NJ</th>
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<tr>
<td>Washington DC</td>
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<td>18</td>
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</tbody>
</table>

RTT in ms Between GW POP and Aggregation POP
Can Offload/Distribution Improve Bottom 10%-ile User Experience?

- Delay across cellular interface diminishing from 250ms with 3G, 100ms with HSPA to 15ms with LTE
- Opportunity for 10%-ile worst subscribers to benefit from saving ~40ms RTT in terms of experience
3GPP Release 11 Local IP Access
Femto Forum Enterprise Architecture

- **Mobile Operator Network**
  - MSC/SGSN
  - TR-069 OAM

- **Enterprise IP Network**
  - LIPA Gateway
  - Femto Gateway
  - Iu-h/SIP Interworking
  - Enterprise Femto OAM

- **Local Enterprise Network**
  - Enterprise Femto AP
  - Local Enterprise Voice
  - Guest Voice & Data Services

- **Guest**
  - Guest Voice & Data Services
  - Enterprise Femto AP

- **Enterprise User**
  - Local Enterprise Voice
  - Local Enterprise Data

- **Broadband IP N/W**
  - IP N/W
SP WiFi: Leveraging WLC QoS Control?

- SIP based QoS and CAC support but assumes WLC is able to intercept and analyse application signalling

- SIP Based QoS (WLC 6.x)
  - Intercept and snoop SIP traffic (AP: Upstream, WLC: downstream) to determine voice session and set QoS
  - RFC 3261 compliant client

- SIP Based CAC (WLC 7.x)
  - Adding to the SIP Based QoS of Rls 6
  - Enable the network to roam voice session between APs based on available bandwidth
  - Feature is applicable to SIP phone w/o TSPEC.
  - Bandwidth parameters are configured manually on per session bases

Issue that SP WiFi based SIP Voice will likely be based on IMS where SIP signalling is ciphered between host and P-CSCF - preventing interception/analysis by WLC
SP WiFi: Integrating QoS Domains

AF Signalling

Different QoS configuration per SSID

802.11e configuration

802.1p
doctor

IP Admission Control, Gating and Rate Limiting
Mapping Between Different QoS Domains

- IP Address allocated to Endpoint and visible to applications
- IP Address allocated to WiFi AP and subscriber ID known to CMTS

Need a mapping function between subscriber IP@ and tunnel IP@
Agenda

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Summary - 1

- Its only a matter of time before all operators will need to embrace small cells – offloading both bandwidth and signalling load from the macro network
  - Options available: licensed, unlicensed or both

- WiFi already used to support nearly 40% of Smartphone traffic in the US

- Compared to femto where an E2E architecture has been defined by 3GPP, no standard defined approach to architecting SP WiFi

- Over the last 2 years, Cisco has been developing an architecture based on 3GPP standards to enable in integration of SP WiFi users into scalable converged policy and charging infrastructure
Summary - 2

- Now delivering on the promise of E2E SP WiFi architectures
- Driving client ecosystems to deliver HS 2.0 capabilities to automate authentication and deliver a seamless experience
- Small cell installations further allow differentiation enabling direct access to distributed content and services
- Unlikely that similar techniques will be applied in the macro network driven from a purely economic perspective versus enhanced user experience
- Small Cells are driving convergence discussions around how to integrate transport orientated QoS with RF QoS and IP level policy and charging enforcement
Q & A
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