Converged Networks and Mobility

Fixed-wireless convergence on a multi-access broadband edge

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Expanding broadband coverage with fixed-wireless access

Fiber to the home is preferred but it is costly and takes time.

Leveraging existing assets saves time but has diminishing returns.

Fixed-wireless access allows to capture revenues today and reuse fiber for future FTTH.
Fiber-grade broadband over the air

**5G sub 6 GHz**
- Peak rates up to ~1 Gb/s (10 – 25x LTE speeds)
- Sustained rates for HD video streaming
- Indoor gateways or outdoor receivers
- Fits existing mobile network footprint (macro cells)

**5G mmWave (24 – 39 GHz)**
- Peak rates of multiple Gbps
- Sustained rates for 4k TV capabilities (~ 50-100 Mbps)
- Requires outdoor receivers and a clear line of sight
- Network densification with small cells
Multi-access broadband target architecture

Open and programmable network APIs

Any type of access

Multi-access Aggregation
Cost optimized and access-agnostic

Multi-access Edge
Service-agnostic and distributed user plane

Unified control
Seamless, on-demand subscriber experience

Any type of service

5G Core
Cloud-native and converged services
Inherent complexity and functional duplication

1. Smart pre-aggregation layer with dedicated leaf switches
   - Access Plant
   - Cable
   - Fiber
   - Radio
   - DOCSIS
   - OLT
   - eNB/gNB

2. Access - and service agnostic IP/Ethernet aggregation layer
   - Pre-aggregation
   - Aggregation
   - CCAP
   - BNG
   - FWA S/PGW

3. Service-dedicated network gateways
   - Multiple edges
   - Data center
   - AAA
   - PCRF
   - EMS
   - NMS
   - Peering
Evolution to a multi-access broadband network

Extract complexity by moving functions into the cloud

Disaggregate and virtualize access network functions
  ➢ Multi-access aggregation

Decouple and distribute user plane functions
  ➢ Multi-service edge gateway

Virtualize and centralize control plane functions
  ➢ Unified control/core
Multi-access broadband solution ingredients

Access and transport slicing
- Flexible VNF/PNF connectivity: IP-VPN, EVPN overlay
- Multiple underlay options: VXLAN, SR-MPLS, SRoUDP

Virtualized control plane
- Centralized, cloud-native, 5G enabled
- Unified subscriber/session management

Disaggregated user plane
- Distributed, network-native (NPU)
- High-performance broadband
- Cost-efficient internet offload
- Fabric-based IP multicast replication
- Integrated edge security (DDoS)

Virtualized access functions
- Distributed, cloud-native/appliance-based

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How does fixed-wireless access fit in?

### Edge gateway requirements

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Mobile user</th>
<th>Wireline user</th>
</tr>
</thead>
<tbody>
<tr>
<td>User devices</td>
<td>1 (Typically)</td>
<td>&gt; 10 per home</td>
</tr>
<tr>
<td>Service type</td>
<td>Nomadic</td>
<td>Stationary</td>
</tr>
<tr>
<td>Session type</td>
<td>Dynamic</td>
<td>Always on</td>
</tr>
<tr>
<td>Monthly usage</td>
<td>~3-5 GB</td>
<td>100s of GB</td>
</tr>
<tr>
<td>Average speed</td>
<td>10 kbps</td>
<td>1000 kbps</td>
</tr>
<tr>
<td>Gateway location</td>
<td>Centralized</td>
<td>Distributed</td>
</tr>
<tr>
<td>Gateway functions</td>
<td>Virtualized (x86)</td>
<td>Physical (NPU)</td>
</tr>
</tbody>
</table>

### Mobile Gateway
- High-performance control plane
  - Dynamic sessions/elastic scaling
  - Low volume/high revenue per bit
- Compute and storage intensive
  - Virtualized network functions
  - General purpose silicon (x86)

### Wireline Gateway
- High-performance user plane
  - Static user devices/always-on
  - High volume/low revenue per bit
- Bandwidth and packet intensive
  - Physical network appliances
  - Custom routing silicon (NPU)
Fixed-wireless access gateway requirements

Wireless access

- 5G NR
- 4G/LTE
- (Wi-Fi)

Wireline access

- HFC
- L2CCAP
- RMD
- XGSPON

FN-RG (eg. Cable modem)

Fixed-wireless access gateway requirements
- Serving and PDN Gateway support
- High-performance user plane (SPGW-u)
- Integrated or virtualized control plane
- MME/HSS subset (no roaming)

S/PGW

FWA

UE

EPC-NAS

W-AN

FN-RG

Serving and PDN Gateway support
High-performance user plane (SPGW-u)
Integrated or virtualized control plane
MME/HSS subset (no roaming)
Disaggregated broadband gateway with Control and user plane separation (CUPS)

Control and management interfaces

Decoupled control plane (SMF)

Control plane functions
- Session state management
- IP address management
- PEP, AAA client, accounting
- LAC, LNS, TWAG, FWAG, HAG
- Access control, QoS control
- Keep alives: LACP, BFD, etc

User plane functions
- Traffic management/statistics
- Subscriber routing/forwarding
- QoS functions, IPTV multicast
- Keep alives: PPP hellos, etc

Based on 3GPP CUPS interface (Sx/N4)
Multi-access edge convergence on a 5G core

Wireless access
- (e)LTE
- 5G NR

Wireline access
- Wi-Fi
- XGSPON
- L2CCAP
- RMD
- HFC
  (eg. Cable modem)

5G Core
- AMF
- UDM
- PCF
- NSSF

Multi-access gateway UPF

Key features
- Common SMF for fixed-mobile converged interworking
- UPF with Packet Forwarding Control based on 3GPP Sx/N4 interface
  - Dynamic UPF selection based on APN/DNN, IP address range, etc
  - Flow steering of 5G service traffic to mobile cloud gateway
  - Off-load video and internet
- 5G Access Gateway Function for wireline interworking (optional)
Fixed-wireless converged broadband opportunities

Brownfield
Complement wireline for better experience and service coverage

Greenfield
Compete with rapid coverage and short time to revenue

5G services
Combine fixed and wireless access for cost-efficiency and a seamless user experience

To the core
Cloud-native services for elastic scaling and high service velocity

Over the wires
Multi-access aggregation and edge for optimal cost and performance synergies
Thank You!

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