

Public Safety Spectrum Trust Operator Advisory Committee (PSST-OAC) Interconnectivity Infrastructure Group (IIG)

V19.0, March 9, 2012

With update from March 8, 2012 OAC Meeting

Participating organizations who participated substantively and contributed to the analysis contained herein:



Alcatel·Lucent



ERICSSON



MOTOROLA SOLUTIONS

Nokia Siemens
Networks



ANDREWSEYBOLD

HARRIS



IPWireless



PSCR

Public Safety Sponsors:



The Interconnectivity Infrastructure Group (IIG)

- IIG consists of lead architects from nine organizations
- On 12/1/2011 the team agreed to complete a high level interconnectivity architecture in 30 working days from official kickoff
- ***All content has been jointly developed, reviewed by all participants and represents a consensus view of the IIG working team.***

Co-Chairs

Chuck Robinson - City of Charlotte
Andy Seybold - Andrew Seybold, Inc.

IIG Working Team

Alcatel-Lucent – Wim Brouwer
Cynergyze – Cynthia Wenzel Cole
Ericsson – Patrik Ringqvist
Harris – Reid Johnson
IPWireless – Keith Sinclair
MSI – Gino Scribano
Nokia-Siemens Networks – Brian Kassa
PSCR – Emil Olbrich, Jeff Bratcher

Executive Advisors

Bill Schrier – PSST-OAC Chair
Harlin McEwen – PSST Chair

TERMINOLOGY & PHASING

Terminology Introduction

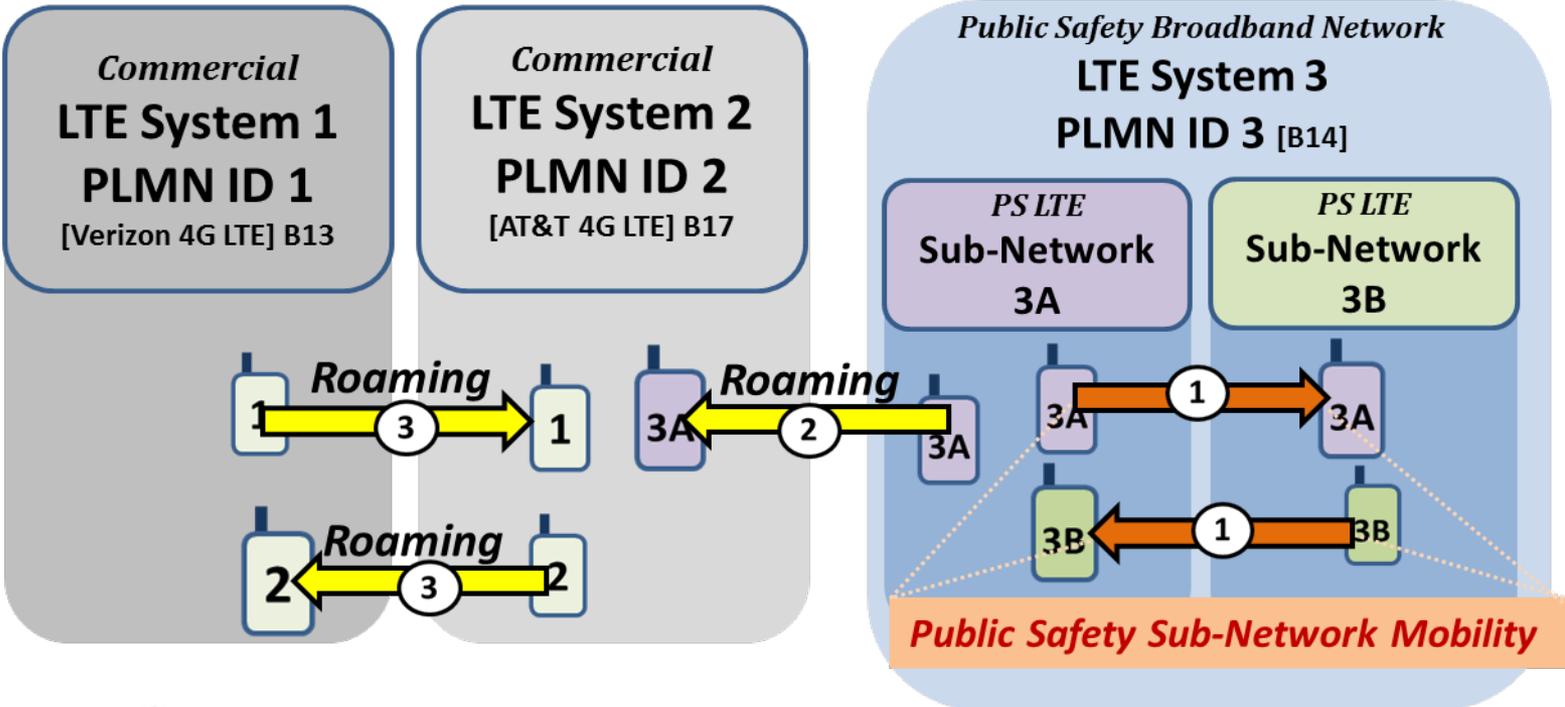
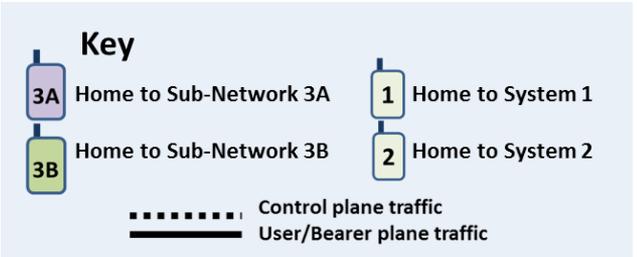
- Our terminology is not keeping up with intricacies of various roaming and mobility options
 - Improper use of “roaming” term causing confusion
 - “Roaming” specifically refers to movement between networks with different PLMN IDs
- The following material proposes a consistent terminology approach
- Uses existing conventions and standards-based definitions used where ever possible
- For productive discussions, general sub-network illustrations have been developed using the definitions proposed

Proposed Terminology

- **Sub-Network** – The subset of the Public Safety Broadband Network defined by a IMSI/MSIN range within the common PLMN ID. A sub-network provides an HSS for its particular IMSI Range.
- **Public Safety Broadband Network** – The entire Public Safety LTE Network with a common PLMN ID which is comprised of many small sub-networks and which may include a common central part.
- **Public Safety Sub-Network Mobility** – Movement of a user between sub-networks. Service availability across sub-networks is provided by IMSI-range and APN node-selection functionality.
- **Roaming** – Movement of a user between the systems of different PLMN IDs.
- **Home PGW Access (HPA)** - Accessing Home APNs from visited sub-network. As opposed to Home Routed Traffic when Roaming to/from networks with a different PLMN ID.
- **Local PGW Access (LPA)** - Accessing common APNs via local PGWs in visited sub-network. Common APNs need to be implemented in each sub-network. As opposed to Local Breakout (LBO) Traffic when Roaming to/from networks with a different PLMN ID.

Basic Roaming & Mobility Terms

"3A" – 1st PS LTE
 "3B" – 2nd PS LTE
 "3C" – 3rd PS LTE
 "3D" – 4th PS LTE



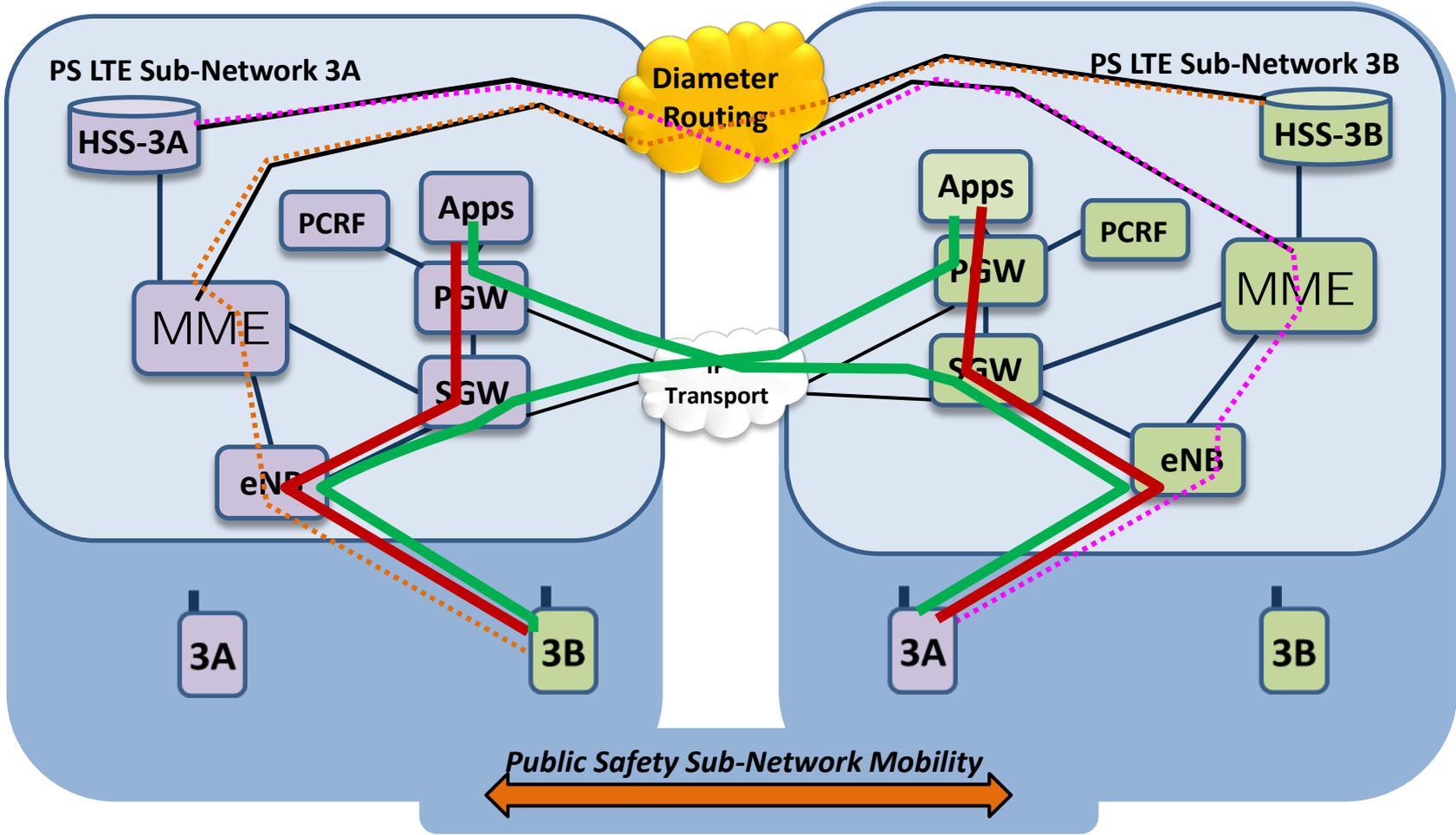
- ① **Public Safety Sub-Network Mobility**
 - User 3B moving from Sub-Network 3B to Sub-Network 3A
 - User 3A moving from Sub-Network 3A to Sub-Network 3B
- **Roaming**
 - ② User 3A moving from Sub-Network 3A to LTE System 2
 - ③ User 1 moving to System 2 or User 2 moving to System 1

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Connecting PS LTE Sub-Networks

Showing connectivity service details including LPA and HPA services



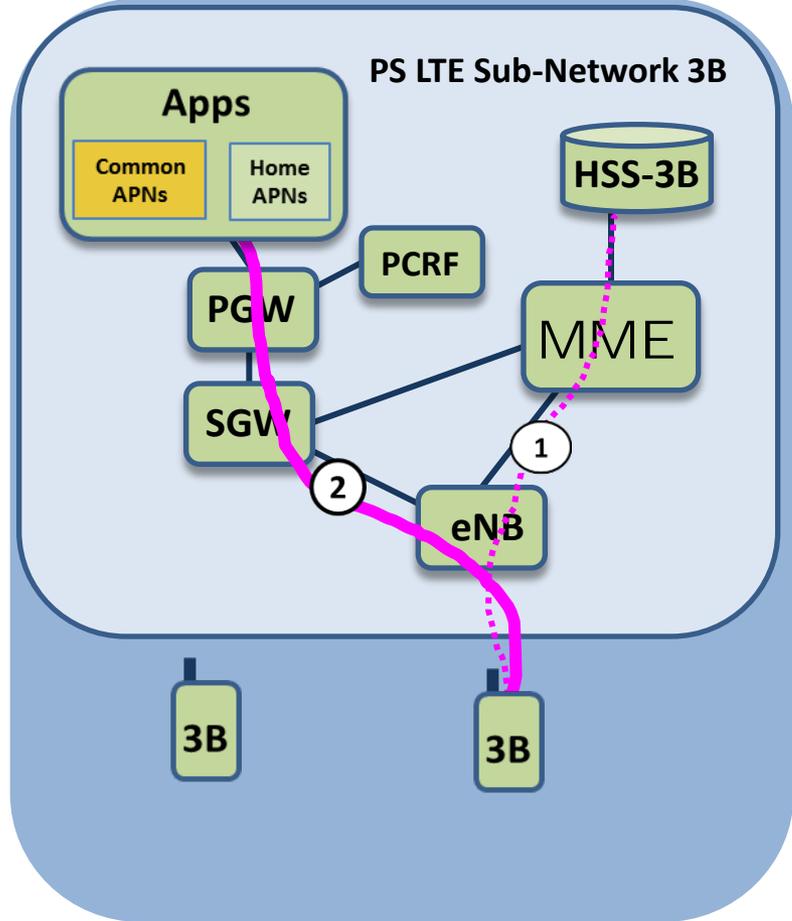
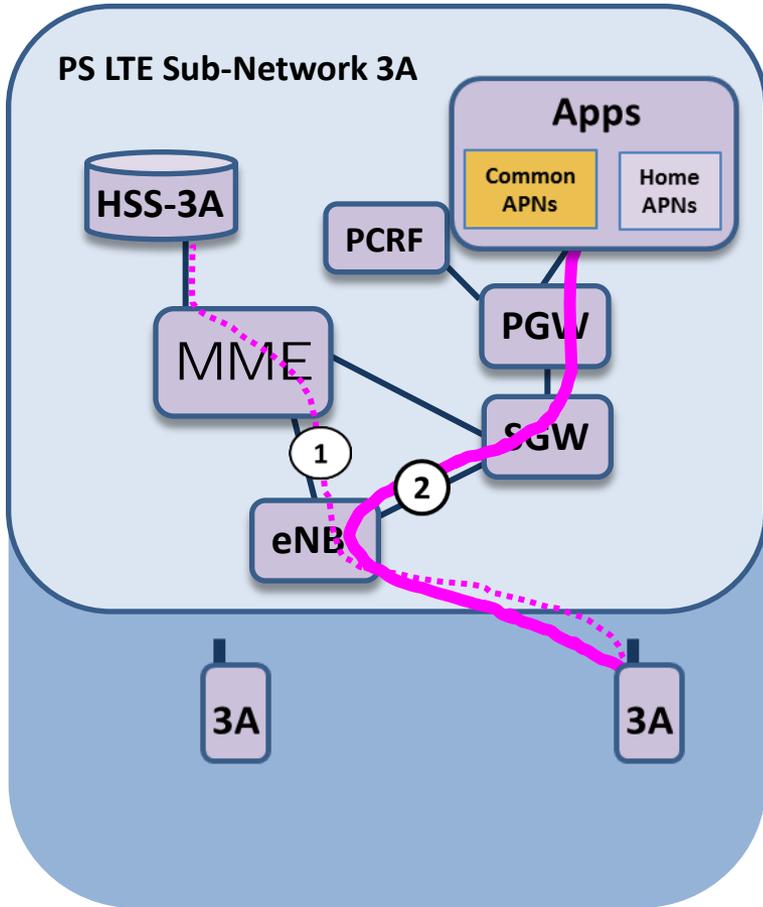
..... Visiting UEs authenticating to Home HSSs
 ——— Local PGW Access (LPA)
 ——— Home PGW Access (HPA)

Proposed Terminology

- **Common APN** – A well-known APN name which will resolve to the PGW associated with the current serving PS Sub-Network, or if there are multiple PGWs serving the coverage area, it will resolve to the PGW closest to the current location of the UE based on DNS.
 - Requires a common name for the APN, e.g.:
FQDN=local.publicsafety.apn.epc.mnc911.mcc312.3gppnetwork.org
- **Home APN** – APN that resolves to a PGW serving the Home jurisdiction irrespective of the current serving PS Sub-Network. Home APNs may be restricted to users of the home jurisdiction.
 - Requires the ability for the local DNS to resolve the FQDN to the home PGW IP address, e.g.:
FQDN=charlottepd.publicsafety.apn.epc.mnc911.mcc312.3gppnetwork.org

PS LTE Delivering Initial Operability

UEs operating within Home PS LTE Network



- ⋯ ① CONTROL/Signaling - Home UE authenticates to Home HSS
- ② USER/Bearer - Home UE uses Home-based services

ASSUMPTIONS FOR INITIAL INTERCONNECTIVITY

General Assumptions

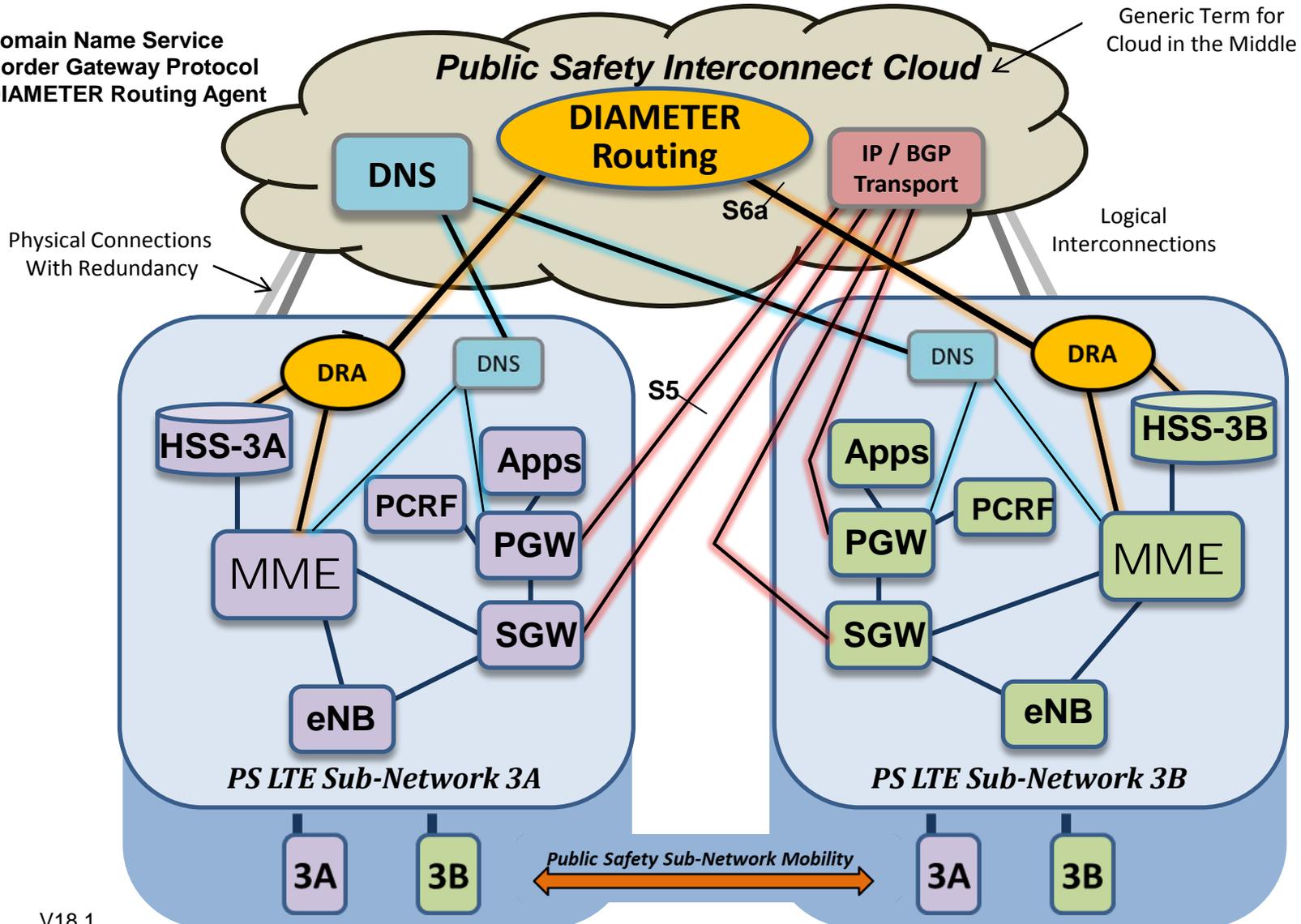
- A single, common, operational PLMN ID will be used for all interconnecting PS Sub-Networks
 - PS to appoint entity to apply to ATIS for PS PLMN ID
- Agreement will be reached on the mechanism to assign blocks of IMSI numbers to local networks in the timeframe required by the early adopters
 - This is a key requirement to ensure that DRA routing infrastructure can be instantiated
- Roaming access to commercial networks OUT OF SCOPE for IIG but will be considered in the design
- Services may be introduced in phases

Assumptions – Early Adopters Interconnection

- Compliant with FCC Waiver Orders
 - *Interoperability Order* DA 10-2342, December 10, 2010, subsection A
 - *May Waiver Order*, FCC 10-79, May 12, 2010, ¶46.
 - *Interop Showing Guidelines* DA 10-923, May 21, 2010
 - *Common PLMN ID Order*, DA 12-25, January 9, 2012
- Four Early Adopters requiring interconnection
 - Adams County, CO; City of Charlotte, NC; State of Mississippi; Harris County, TX
 - 2Q2012 Timeframe for first two deployments: HC BIG-Net and City of Charlotte
 - Interconnection plan complete: February 2, 2012
 - Interconnection technology ready for deployment upon availability of 2nd network going online
- Interconnection interfaces and attributes
 - S6a
 - S5 GTPv1 (bearer only)
 - IPv4 interfaces (S5 or S6a only)

Interconnectivity Using Interconnect Cloud

DNS – Domain Name Service
 BGP – Border Gateway Protocol
 DRA – DIAMETER Routing Agent



V18.1

This illustration shows functional elements which could be instantiated in multiple, single or consolidated devices (boxes).

IMPLEMENTATION OPTIONS

Statement in DA 10-2342, A1

Section A. Public Safety Roaming on Petitioners' Networks

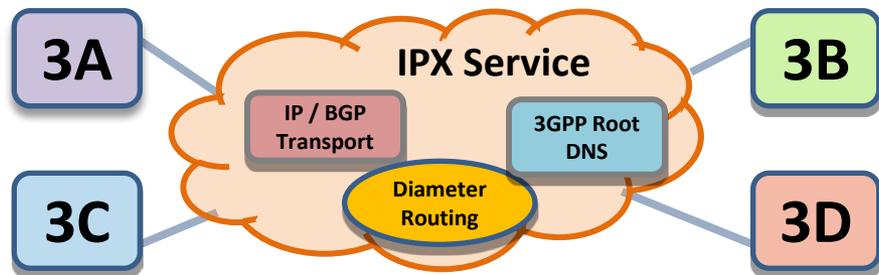
- Paragraph 9 *“Roaming is one of the most basic forms of interoperability, in that it allows “visiting” devices and users to access a local or “host” network for purpose of communicating. In the Waiver Order, we required Petitioner’s system to be capable of supporting roaming by all other Petitioners’ systems and by public safety systems deployed in the future.”*
 - With single PLMN ID, this equates to supporting “Public Safety Sub-Network Mobility” as defined previously
- The order goes on to state, *“We continue to require at ERIC’s recommendation, that technical roaming capability, for both **home-routed** and **local breakout** traffic, be available on the date that a Petitioner’s network achieves Service Availability.”*
 - With single PLMN ID, home-routed equates to supporting Home PGW Access (HPA) as defined previously
 - With single PLMN ID, local-breakout equates to supporting Local PGW Access (LPA) as defined previously

PS Interconnect Cloud Services

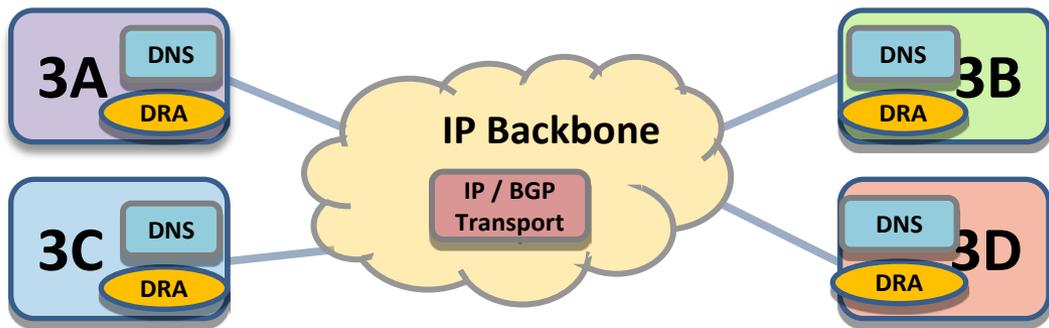
- **DIAMETER with IMSI-Level Routing** – Supports control plane traffic over the 3GPP S6a interface between PS MMEs and HSSs. Each HSS uses a different and unique IMSI/MSIN Range as allocated by the Network Identifier Administrator. It is this connection which allows visiting users to authenticate to their Home HSS.
- **IP Transport using Border Gateway Protocol (IP/BGP Transport)** – This standards based protocol supports the 3GPP S5 interface that carries the User (a.k.a, Bearer) plane traffic using IP protocols operating on commonly deployed BGP routers. It is this connection which allows visiting users to access applications in their home network.
- **Domain Naming Service (DNS)** – Using local APNs names as coordinated by the network identifier administrator, DNS is an essential service which resolves the URLs of the APNs and allows the LTE Device to access the appropriate Packet Gateway (PGW).
 - DNS can either be deployed hierarchically or by replicating DNS data manually, which is referred to as “flat DNS”

Implementation Options – High Level View

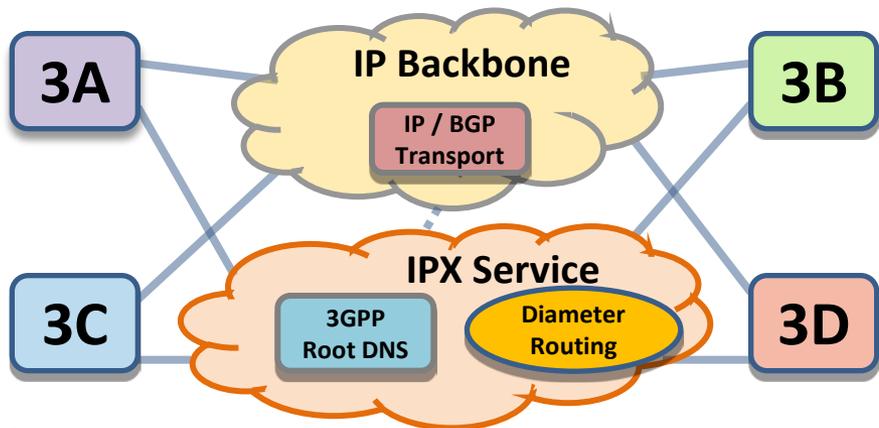
Option 1
 Services Centralized, Provided by
 IPX Service Provider



Option 2
 Generic IP Backbone Provider, no
 central Diameter/DNS services



Option 3
 Hybrid: Generic IP Backbone
 Provider + IPX Service Provider

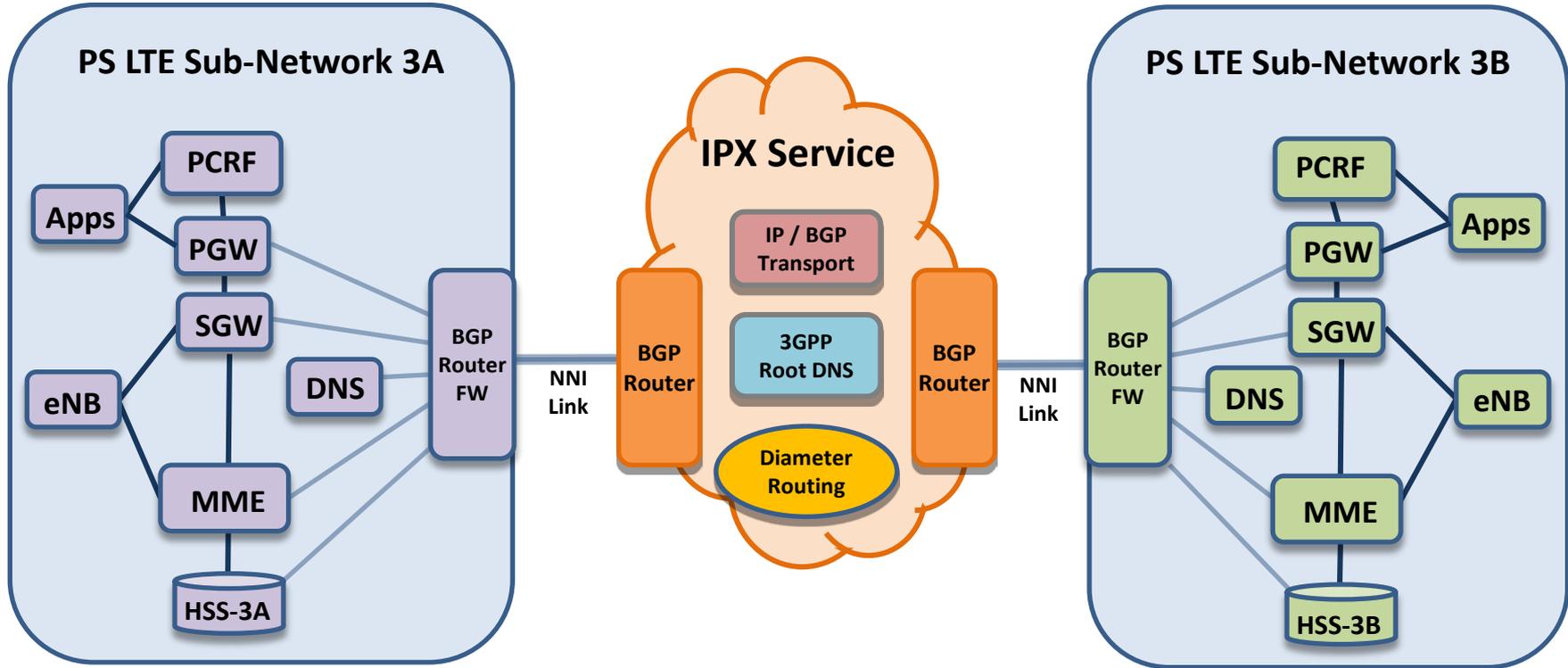


29 Option 1 - Services Centralized, Provided by IPX

Service Provider

Phase 1 - (2) PS LTE Sub-Networks

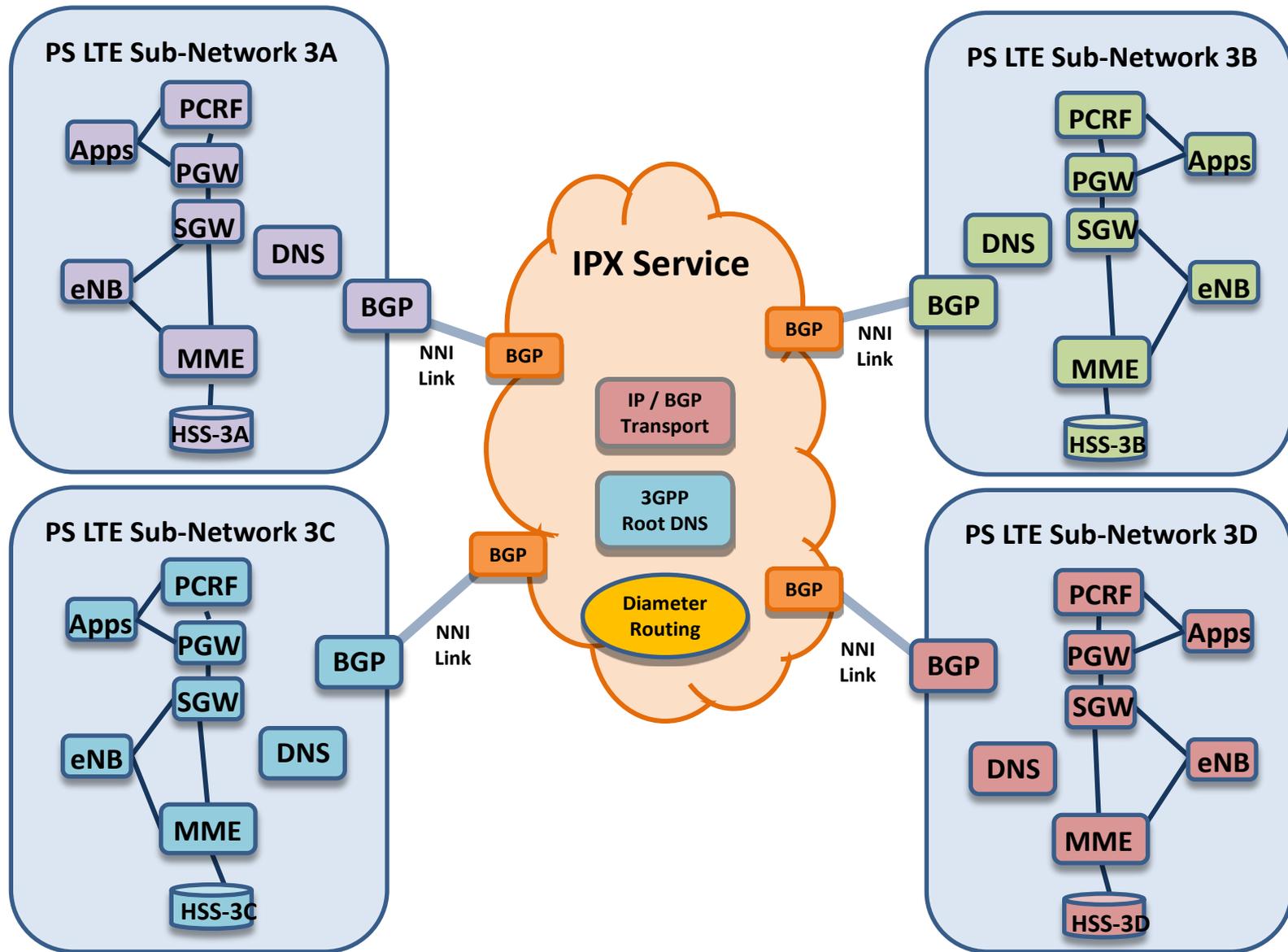
NNI – Network to Network Interface



- The NNI Link from PS LTE Sub-Network location to IPX Service provider location can be responsibility of either PS LTE Sub-Network operator or IPX service provider
- Several options exist for securing the NNI Link (leased T1, Frame Relay, L2 Ethernet, IP VPN, etc.)
- Need full picture of cost to do complete cost/benefit analysis

30 Option 1 - Services Centralized, Provided by IPX Service Provider

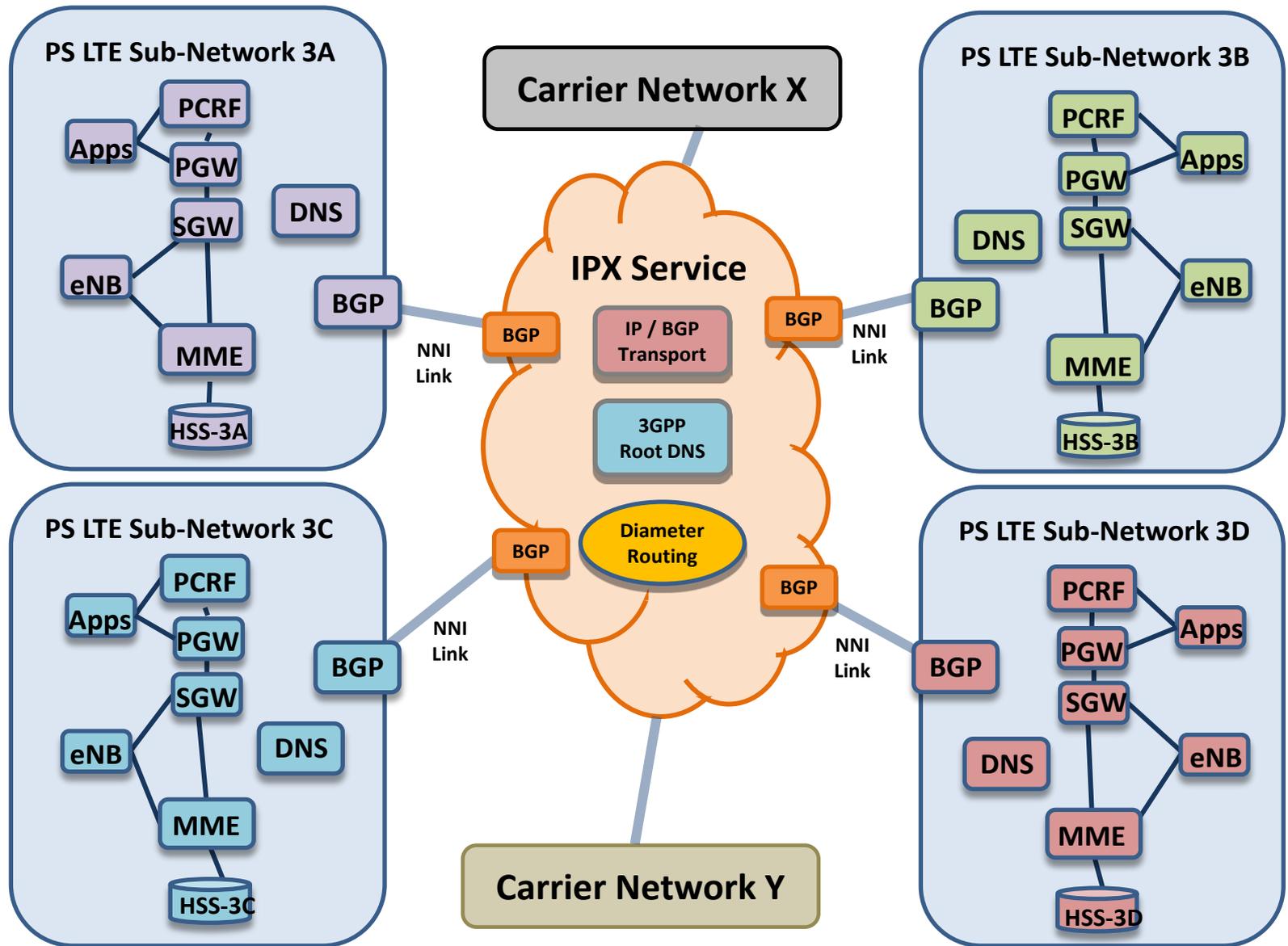
Phase 2 - Additional PS LTE Sub-Networks (4-system example)



Note:
Logical
interfaces
are not
shown

31 Option 1 - Interconnecting Waiver Networks via IPX

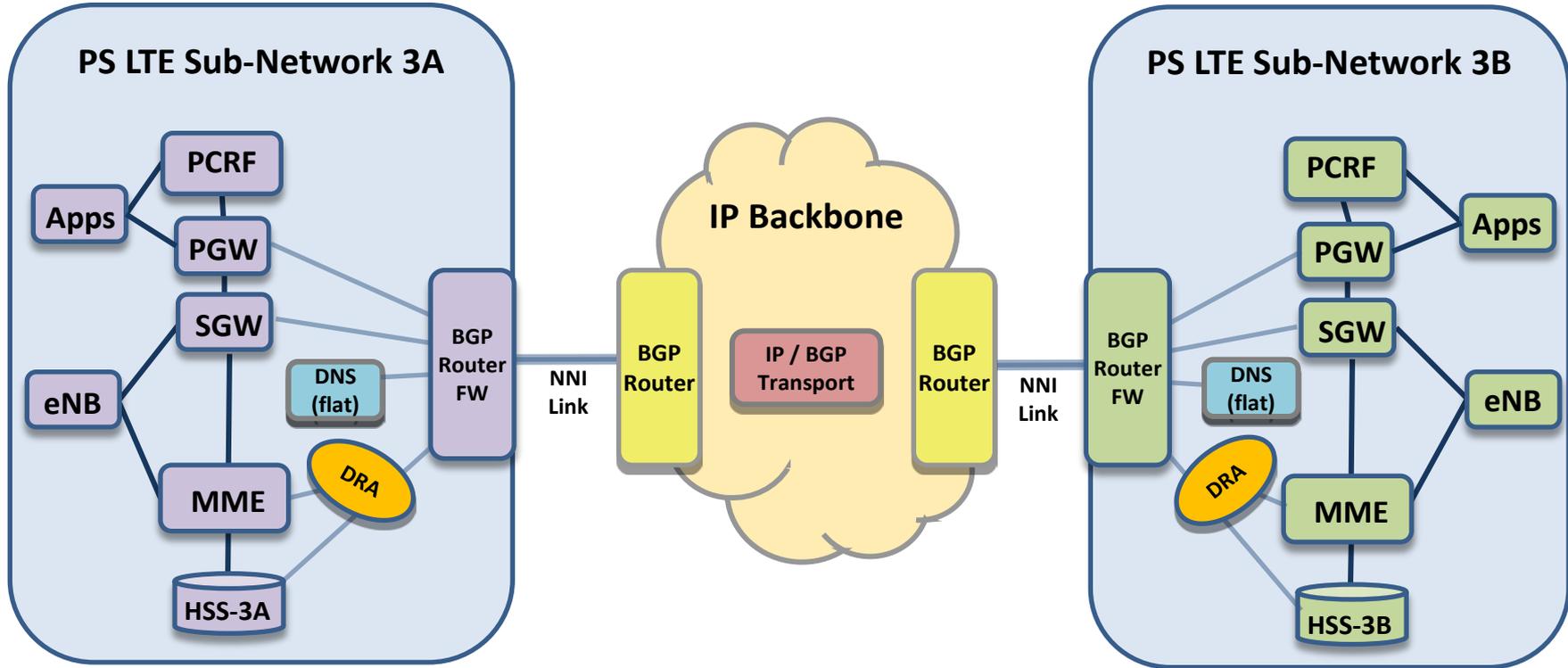
Future Phase - Connect Carrier 4G LTE Network(s)



Note:
Logical
interfaces
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shown

32 Option 2 - Generic IP backbone provider, no centralized DRA/DNS Service

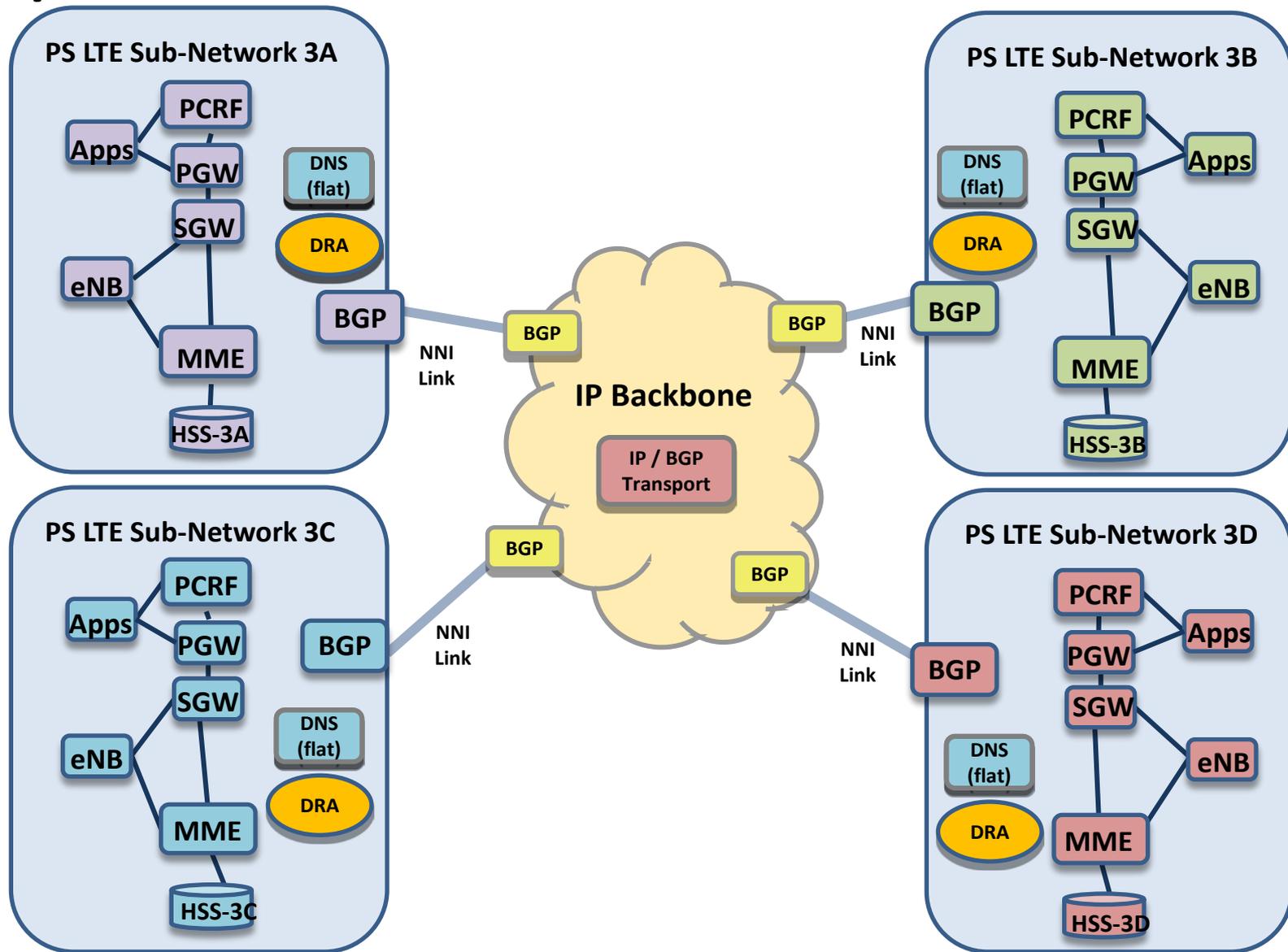
Phase 1 - (2) PS LTE Sub-Networks



- NNI Link from PS LTE Sub-Network location to IP backbone provider location can be responsibility of either PS LTE Sub-Network operator or IP backbone provider
- Flat DNS requires replication function between PS LTE Sub-Networks
- Need full picture of cost to do complete cost/benefit analysis

33 Option 2 - IP backbone provider, no centralized DRA/DNS Service

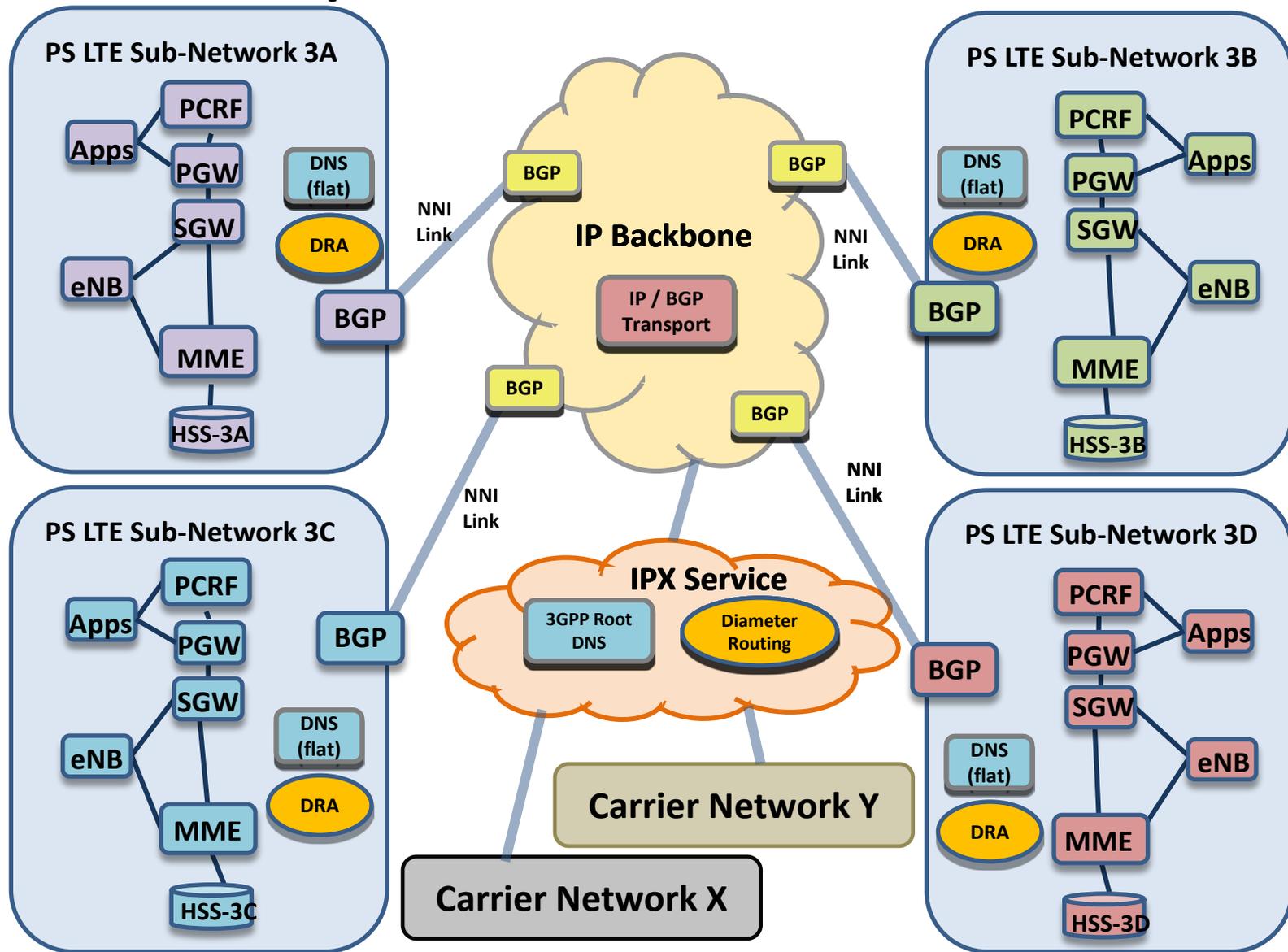
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34 Option 2 – Generic IP backbone provider, no centralized DRA/DNS Service

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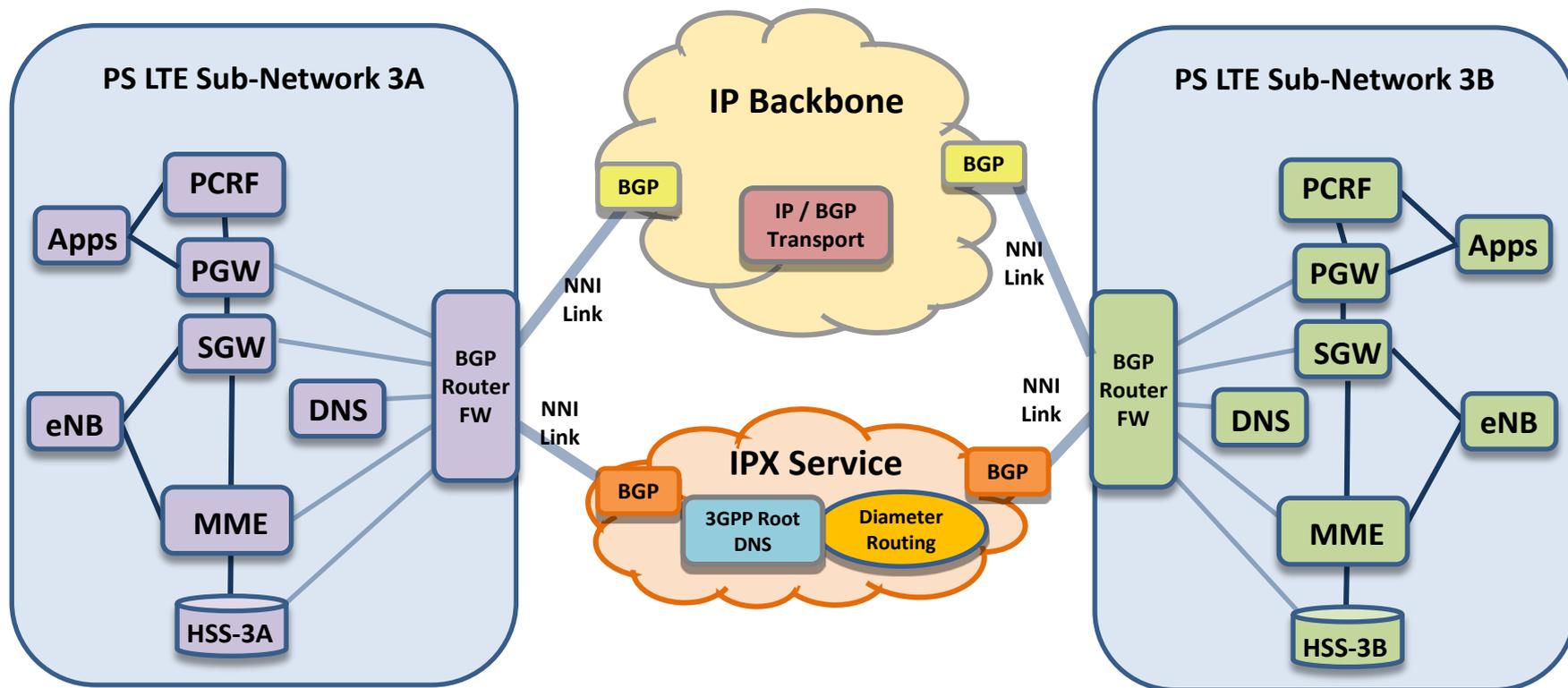


Note:
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interfaces
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Option 3 - Hybrid: IP backbone + IPX Provider

Use IPX for S6a/DNS and IP backbone for S5

Phase 1 - (2) PS LTE Sub-Networks



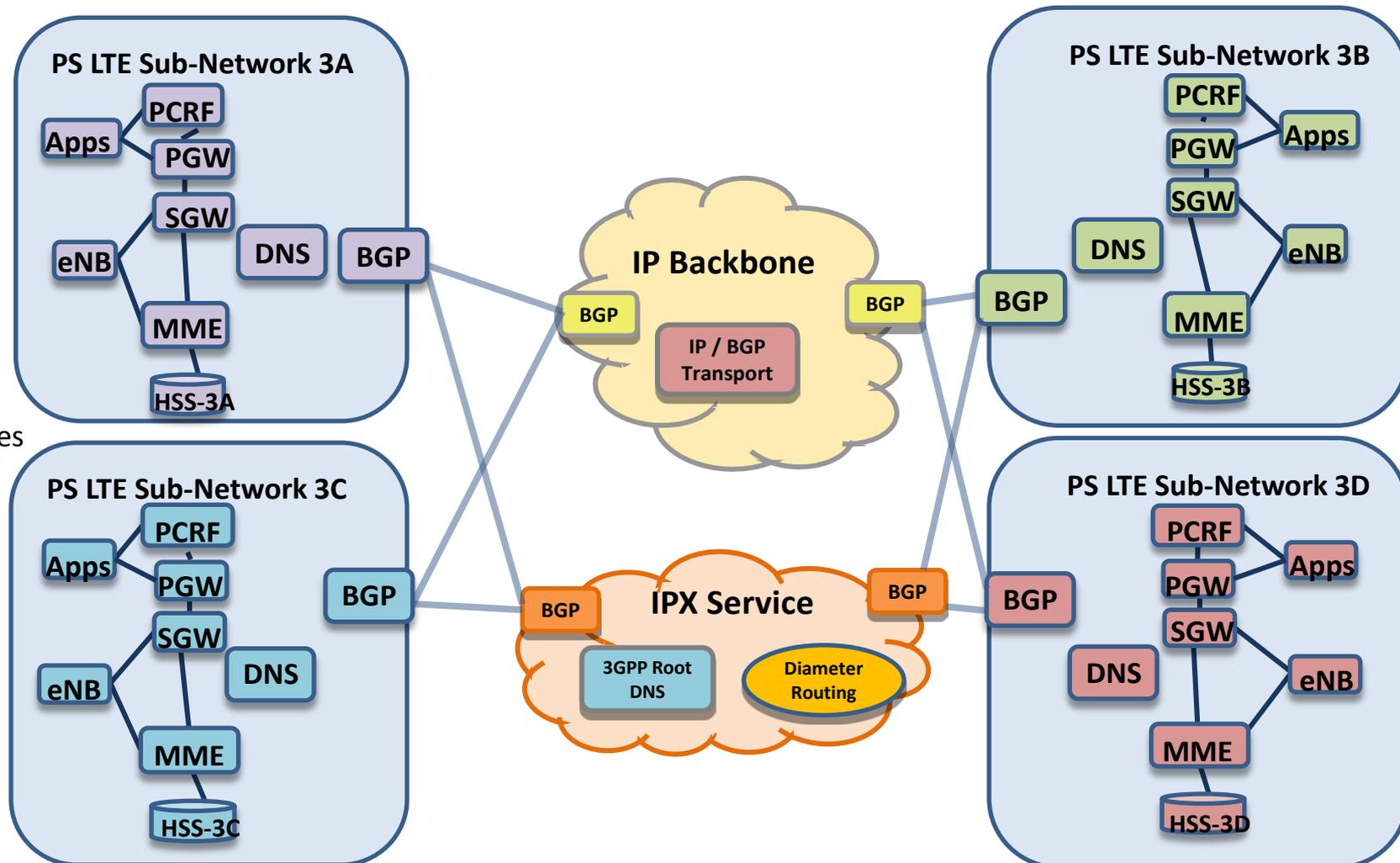
- NNI Link from PS LTE Sub-Network location to Service provider location can be responsibility of either PS LTE Sub-Network operator or service provider
- Several options exist for NNI Link (leased T1, Frame Relay, L2 Ethernet, IP VPN, etc.)
- Need full picture of cost to do complete cost/benefit analysis

Option 3 - Hybrid: IP backbone + IPX Provider

Use IPX for S6a/DNS and IP backbone for S5

Phase 2 - Additional PS LTE Sub-Networks (4-system example)

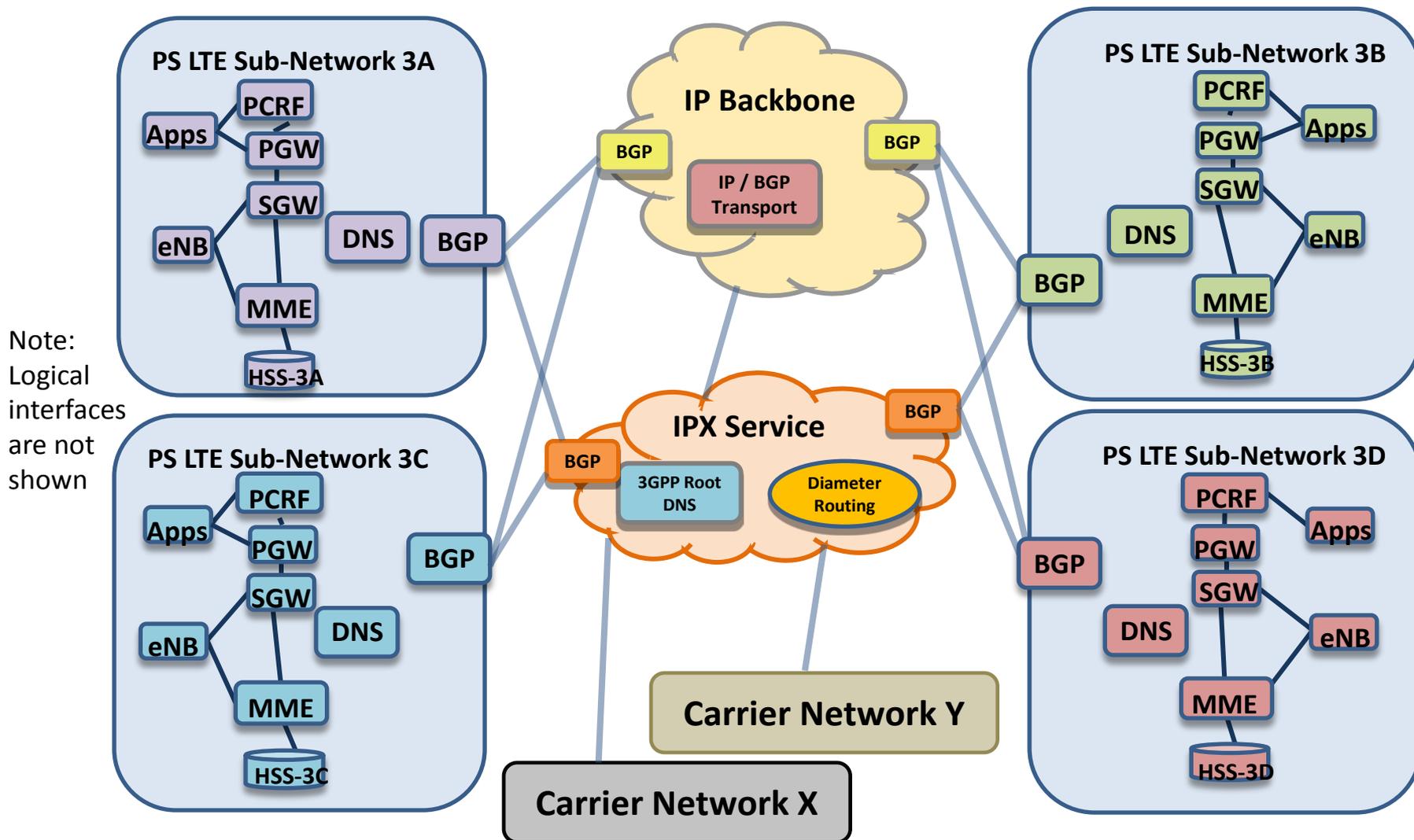
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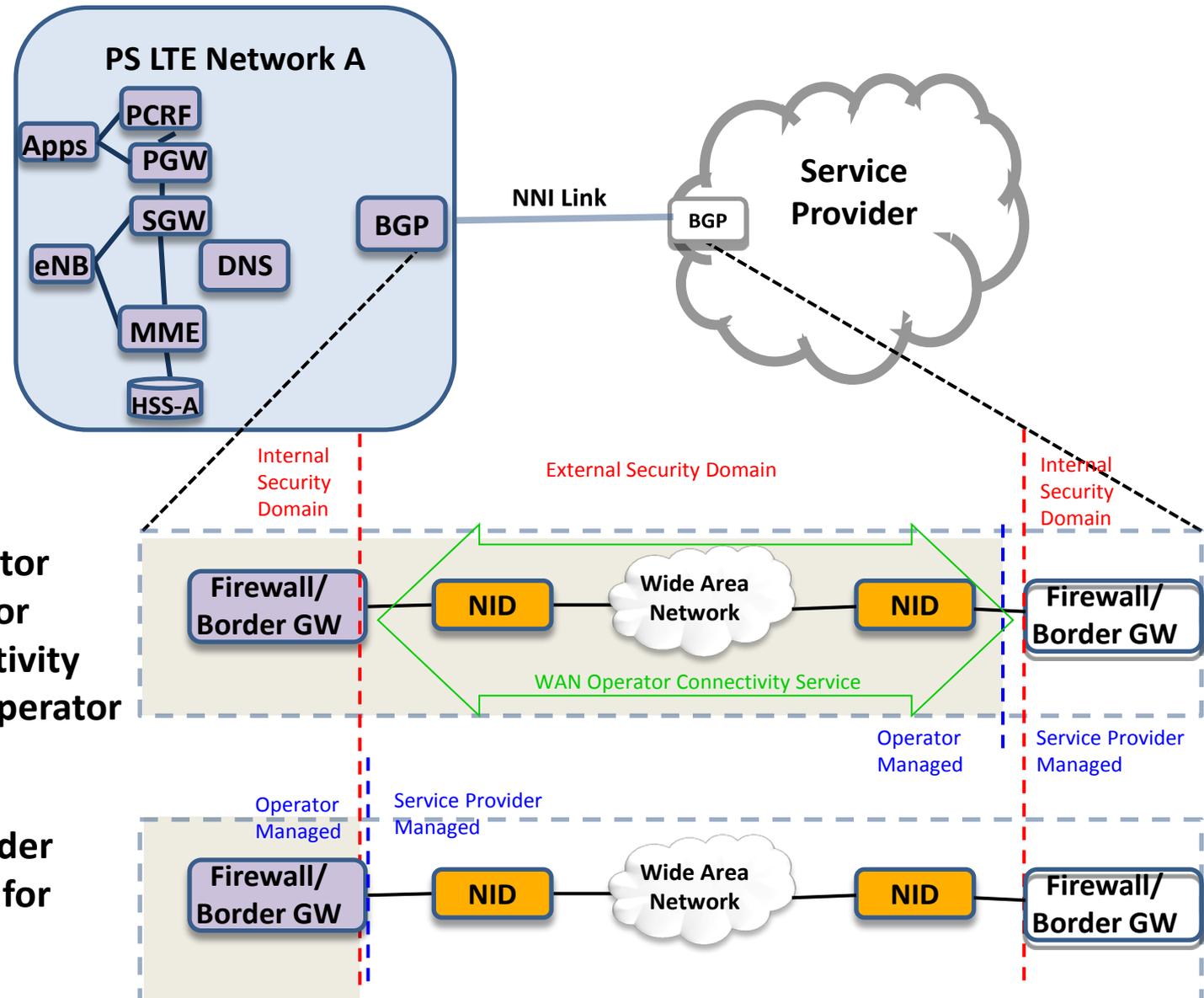
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Use IPX for S6a/DNS and IP backbone for S5

Future Phase - Connect Carrier 4G LTE Network(s)



37.2 NNI LINK OPTIONS



Network Operator Responsible for NNI Link, connectivity provided by WAN operator

Service Provider Responsible for NNI Link

OPTIONS ASSESSMENT

Option 1 Overview

Description

Option 1 consolidates three primary services into a single cloud provider, centralizing the services.

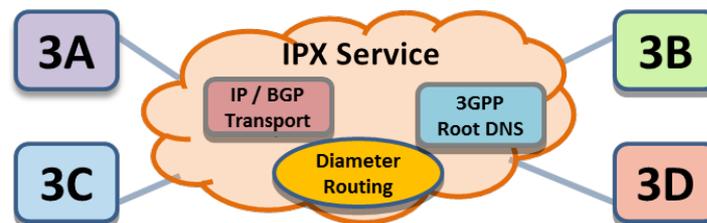
Assumptions

- All Sub-Networks would deploy secure, reliable connectivity to IPX location.
- Assume one O&M domain

Differentiating Advantages

- Easy to add Clearinghouse services
- Easy to implement Carrier Roaming agreements
- Most manageable (O&M)
- Single procurement
- Highly Scalable

Option 1 Services Centralized, Provided by IPX Service Provider



CAPEX/OPEX Summary

- High OPEX solution
- Low CAPEX
 - Sub-Ns require minimal network equipment

Differentiating Disadvantages

- Dependent upon single vendor
 - Dependency on single vendor a near-term constraint
 - Due to current lack of DRA-based interconnectivity among commercial IPX providers for LTE systems

Option 2 Overview

Description

Option 2 puts the Diameter Routing Agents (DRA) and DNS into each Sub-Network, requiring only a basic IP backbone provider for the cloud.

Assumptions

- All Sub-Networks would deploy secure, reliable connectivity to IP backbone provider.

CAPEX/OPEX Summary

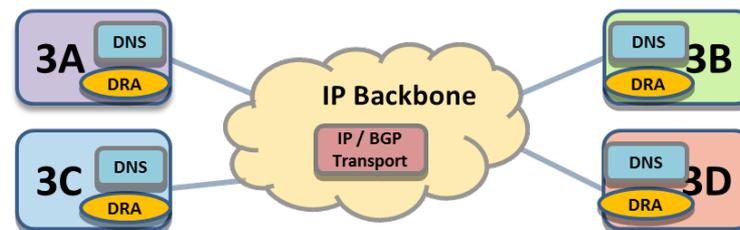
- Highest initial capital outlay for Sub-N Operators
- Only IP on backbone = lowest OPEX
- Highest total cost due to duplication of equipment

Differentiating Advantages

- **Largest number of suppliers to choose from**
- **Easiest to procure**
- **Better survivability**
 - Distributed DRA & DNA
 - General resilience of IP backbones
- **More traffic and eqt in PS trusted domain is inherently more confidential**

Option 2

Generic IP Backbone Provider, no central Diameter/DNS services



Differentiating Disadvantages

- **Highest management burden on Sub-Network**
 - Increases security vulnerability
 - Largest workload for Sub-N support
- **Distributed network difficult to scale**
- **Distributed DNS (flat) & DRA**
 - Increases O&M complexity
 - Carrier integration more difficult
 - Requires changes for every new Sub-N
- **Difficult to add clearinghouse functions**

Option 3 Overview

Description

Option 3 divides the services between two cloud providers, requiring two sets of connections from each Sub-Network.

Assumptions

- All Sub-Networks would deploy secure, reliable connectivity to IP backbone provider.

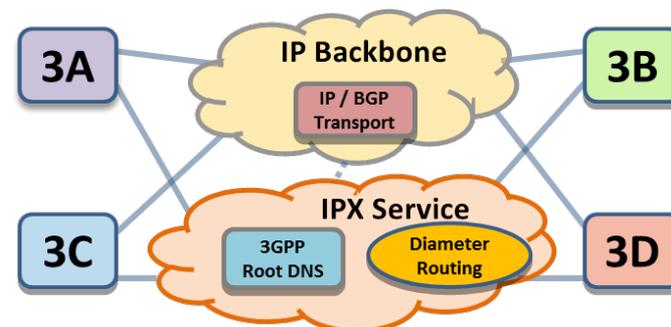
CAPEX/OPEX Summary

- Two clouds = 2x backhaul = Higher OPEX
- Slightly higher CAPEX due to more network connections

Differentiating Advantages

- Enables the most competition
 - Especially for IP/BGP services
- Most procurement flexibility
- One of the more survivable options

Option 3 Hybrid: Generic IP Backbone Provider + IPX Service Provider



Differentiating Disadvantages

- Requires two O&M domains
- Highest backhaul cost
- Complex procurement
- Complex accounting (FCAPS)
- Carrier integration requires interconnectivity btw services be added
- Differing SLAs for control & bearer planes could result in added deployment complexity

Final Assessment Summary

Color Key	
Consolidated Summary Score Rounds to 4 (BEST)	BEST
Consolidated Summary Score Rounds to 3 (BETTER)	BETTER
Consolidated Summary Score Rounds to 2 (GOOD)	GOOD
Consolidated Summary Score Rounds to 1 (OK)	OK

<i>NOT In Order of Importance, Not Weighted</i>	Option 1	Option 2	Option 3
Assessment Summary, v4	Single IPX Provider	IP Backbone DRA, DNS in each Sub-N	Hybrid
Network Security	3.8	2.2	3.2
Short Term Scalability	4.0	1.4	3.2
Ability to Support Commercial Carrier Integration	4.0	1.8	3.1
O&M Simplicity	3.9	1.6	2.7
Survivability	3.6	3.0	3.0
Business Flexibility	2.1	1.9	2.2
Cost Efficiency	3.1	2.4	2.5

Composite ranking scores

IIG Summary

- IIG Concluding Recommendations
 - It is the consensus of the IIG that **Option 1 – Services Centralized, Provided by IPX Service Provider** is the best solution for a variety of factors articulated.
 - The solution also enables flexibility and growth to accommodate additional networks along with variety of future needs and services
- *On behalf of the IIG, it has been our great honor to participate in such an important part of making the Public Safety Broadband Network a reality!*

Decision Summary from March 8, 2012 OAC Meeting

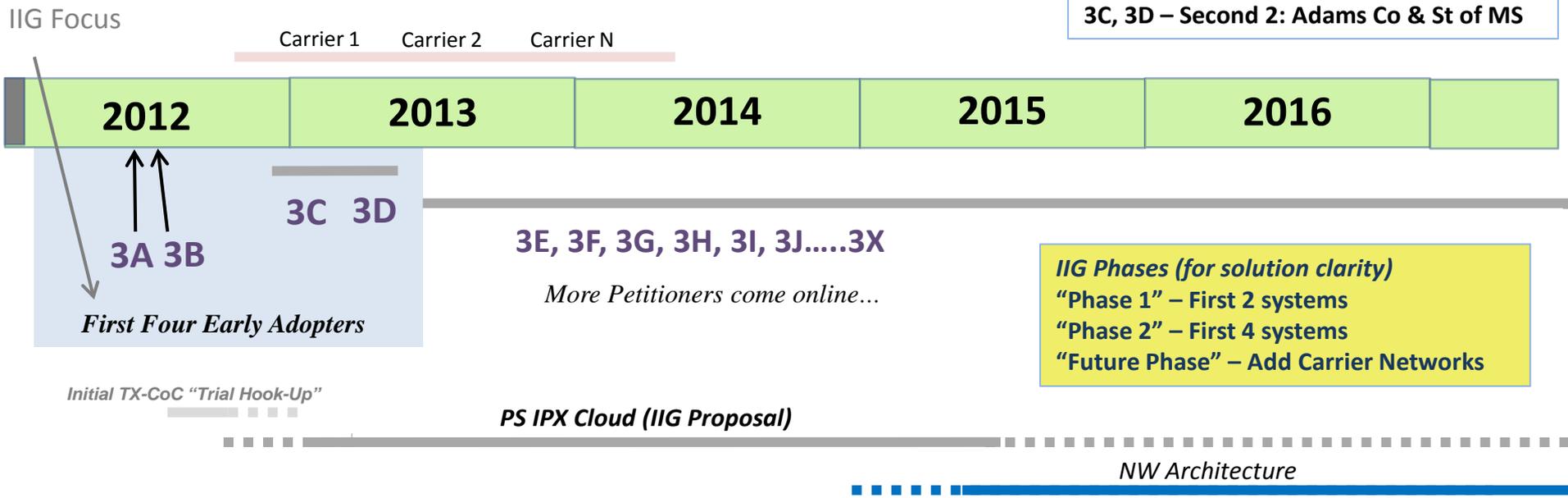
- After a review of the material, including a summary of the differentiating advantages and disadvantages of each option, the OAC unanimously approved Option 1
 - It was acknowledged that this is only an interim solution
 - This represents a directional consensus which will drive interconnectivity among Early Builders
 - The OAC approved filing the summary with the FCC

THANK YOU!

IIG Connectivity in the PS LTE Evolution Timeline

How IIG solution fits into overall PS LTE evolutionary vision

Current Deployment Assumptions
 3A, 3B – First 2: TX & Charlotte
 3C, 3D – Second 2: Adams Co & St of MS



- Reuse of IPX Cloud unclear until nationwide PS BB network is more clearly defined
- Addition of carrier roaming to IPX cloud triggers need for clearinghouse services
 - Requiring interconnection via IPX provider, Data Clearing House (DCH) and Financial FCH Clearing House (FCH) services
- Dates for initial deployment of nationwide PSBN are unknown at this time