Native Deployment of ICN in 4G/LTE Mobile Networks

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Objectives: Provide ICN deployment in 4G/LTE mobile networks (and foundation for 5G), because current research/projects covers

- ICN as an overlay (assuming consumer is attached to the network with IP address and requesting data using ICN messages).
- ICN scenarios to date are either in fixed wireline or WiFi network without involving cellular network.
- Mobile devices will be major video consumers. We need to understand if ICN can help optimize video delivery

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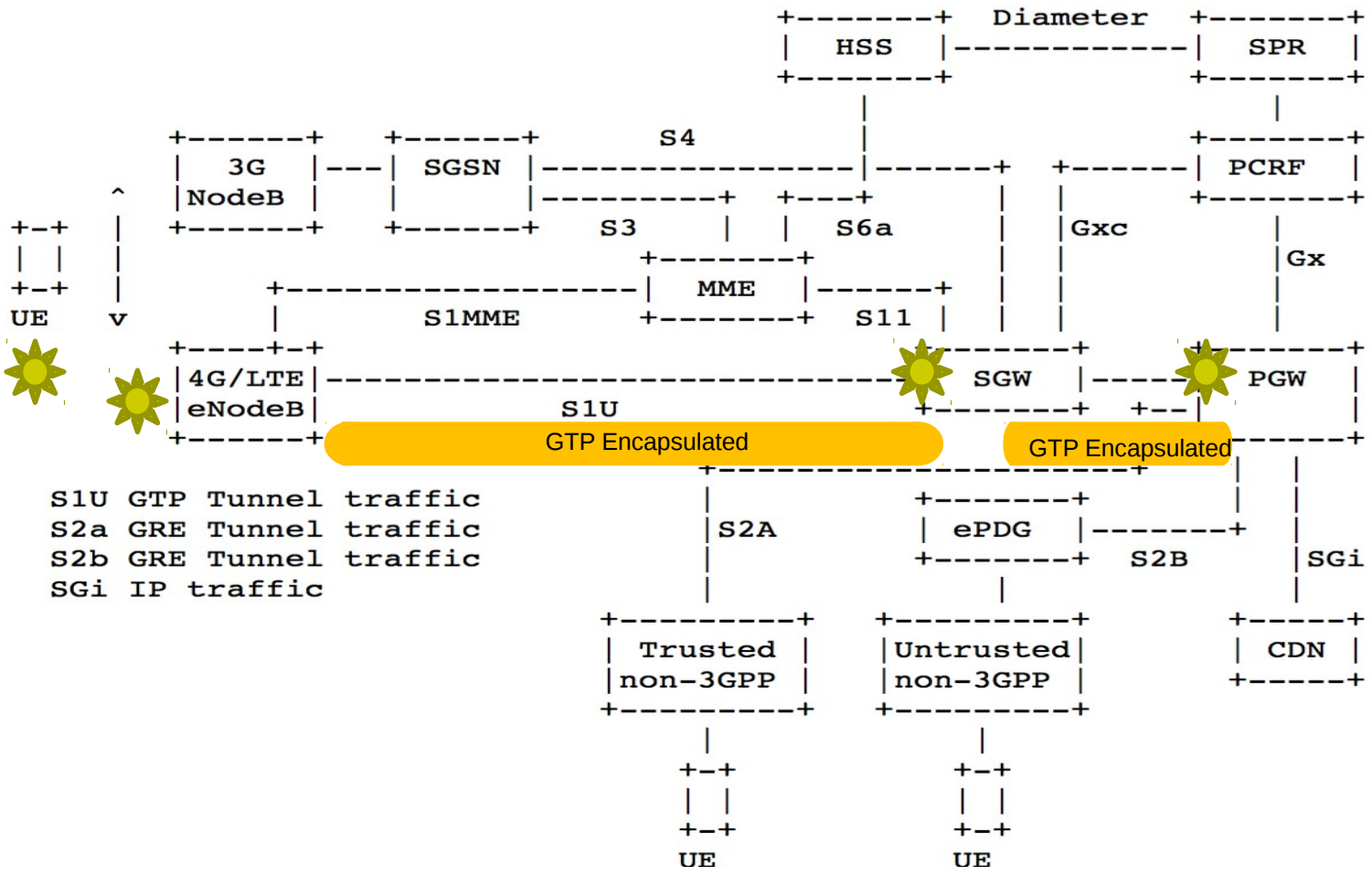
Version 0: March 2017 (initial draft at IETF-98)
Version 1: May 2017 (Feedback from IETF-98)
Version 2: June 2017 (Additional in-depth review and feedback at IETF-99)
Version 3: Sept 2017 (In-depth feedback from ICNRG chair, Akbar and Dirk)
Version-4: Nov 2017 (Feedback from Ravindran) >> **presented at IETF-100**

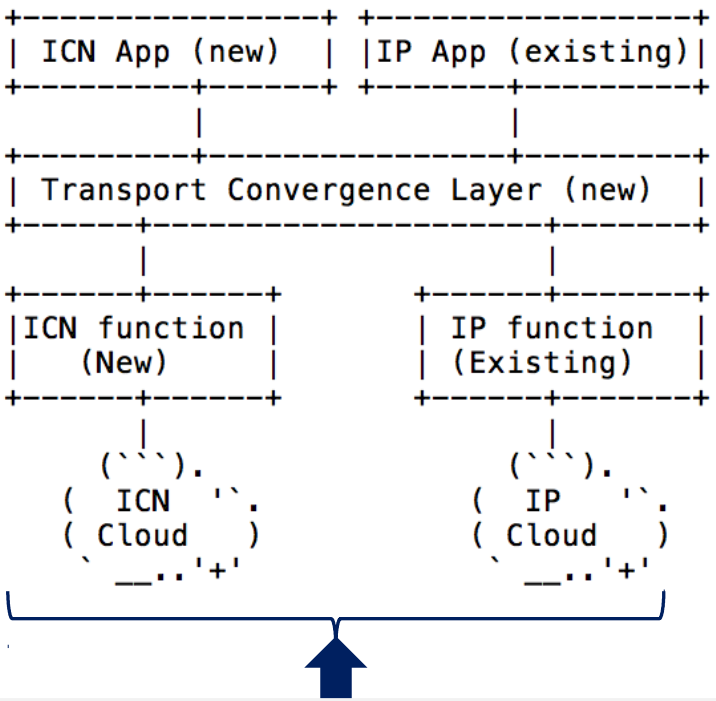
Quick Review of LTE Network



ICN Deployment Scenarios

1. **IP over IP**
   - UE IP datagram is uses IP transport
2. **ICN over ICN**
   - UE has ICN capable applications and it uses ICN transport infrastructure. Packets are directly forwarded using ICN protocol stack, which in turn sends the packets over the ICN transport
3. **ICN over IP (ICNoIP)**
   - UE has ICN but it uses IP transport. ICN is implemented, as an IP overlay
4. **IP over ICN (IPoICN)**
   - UE has got IP application however transport is ICN.
   - Need inter- working function (IWF/Border Gateway) to translate various transport primitives

ICN Deployment Options in UE



ICN forwarder (co-exists with IP) for ICN packets, e.g. Interest packet to eNodeB or response "data packet" from eNodeB to the application

- Select the transport (e.g. ICN or IP) and radio interface (e.g. LTE, WiFi or both),
- Preference (e.g. content location, content type, content publisher, congestion, cost, QoS etc.)
- API for network slicing

- No changes to lower layers except PDCP support ICN for RLC (sequencing, drop detection, retransmission), ROHC header compression, ciphering/ deciphering

Dual stack (IP/ICN) Deployment in UE

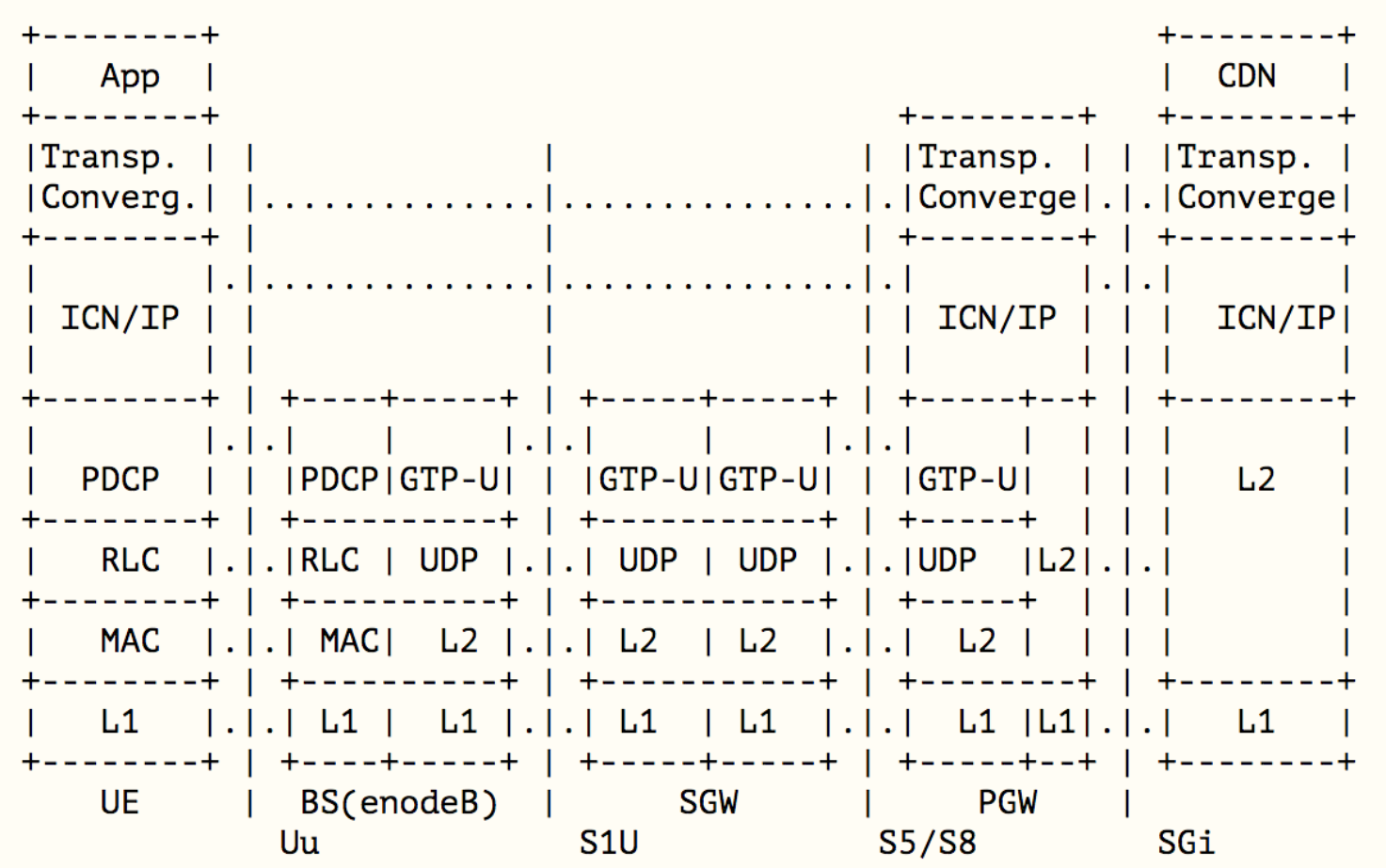


Fig. 6. Dual stack ICN Deployment in UE

Dual stack (IP/ICN) Deployment in UE

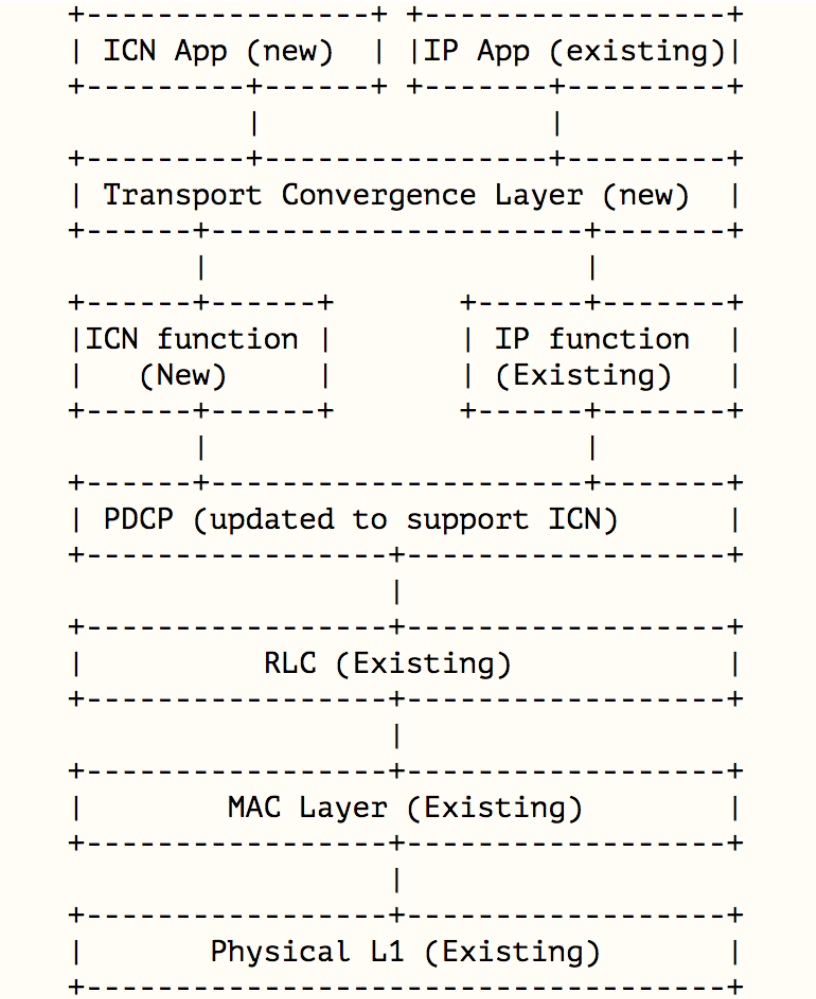


Fig. 7. Dual stack ICN protocol interactions

ICN Deployment in Base Station

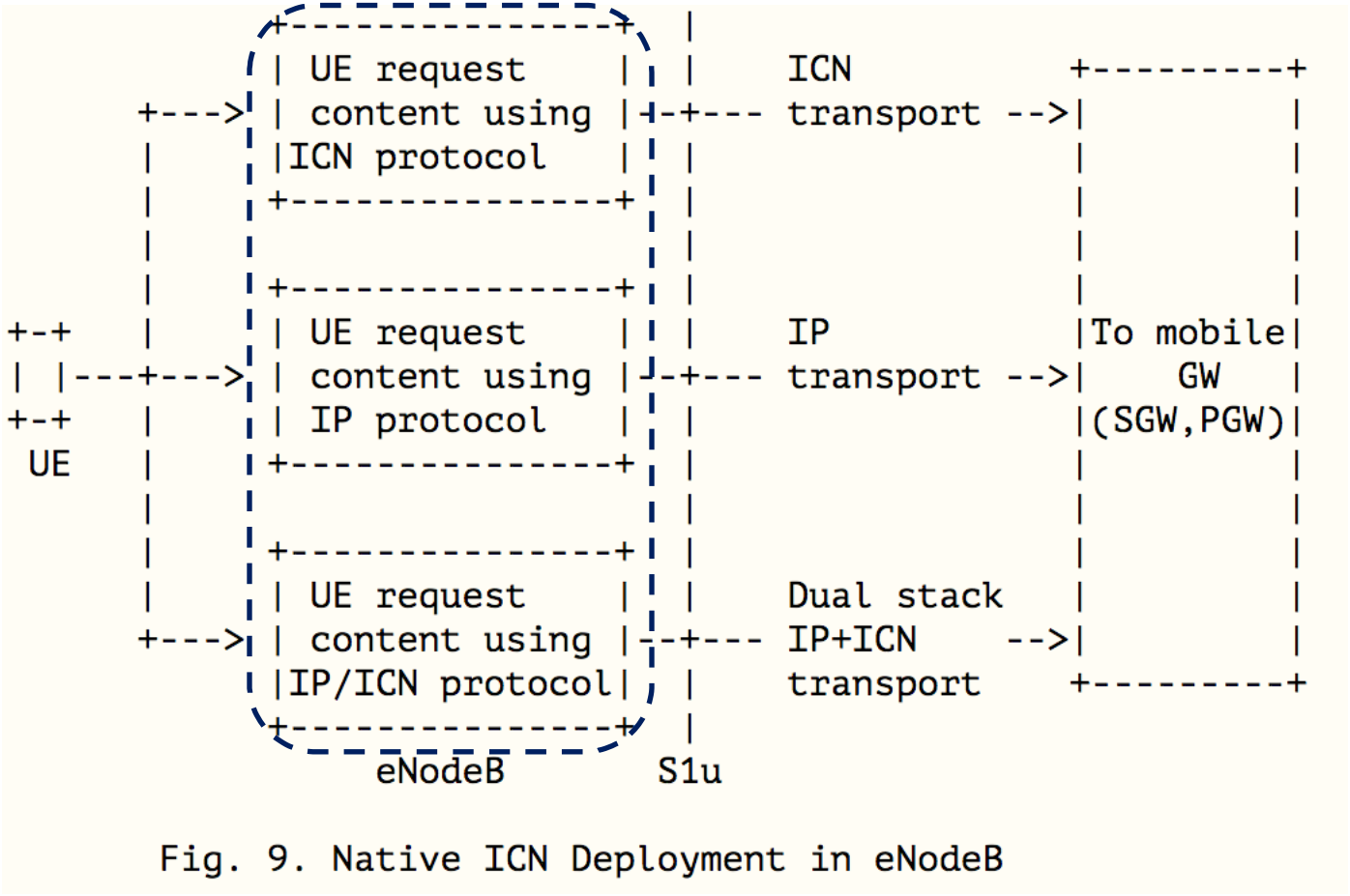
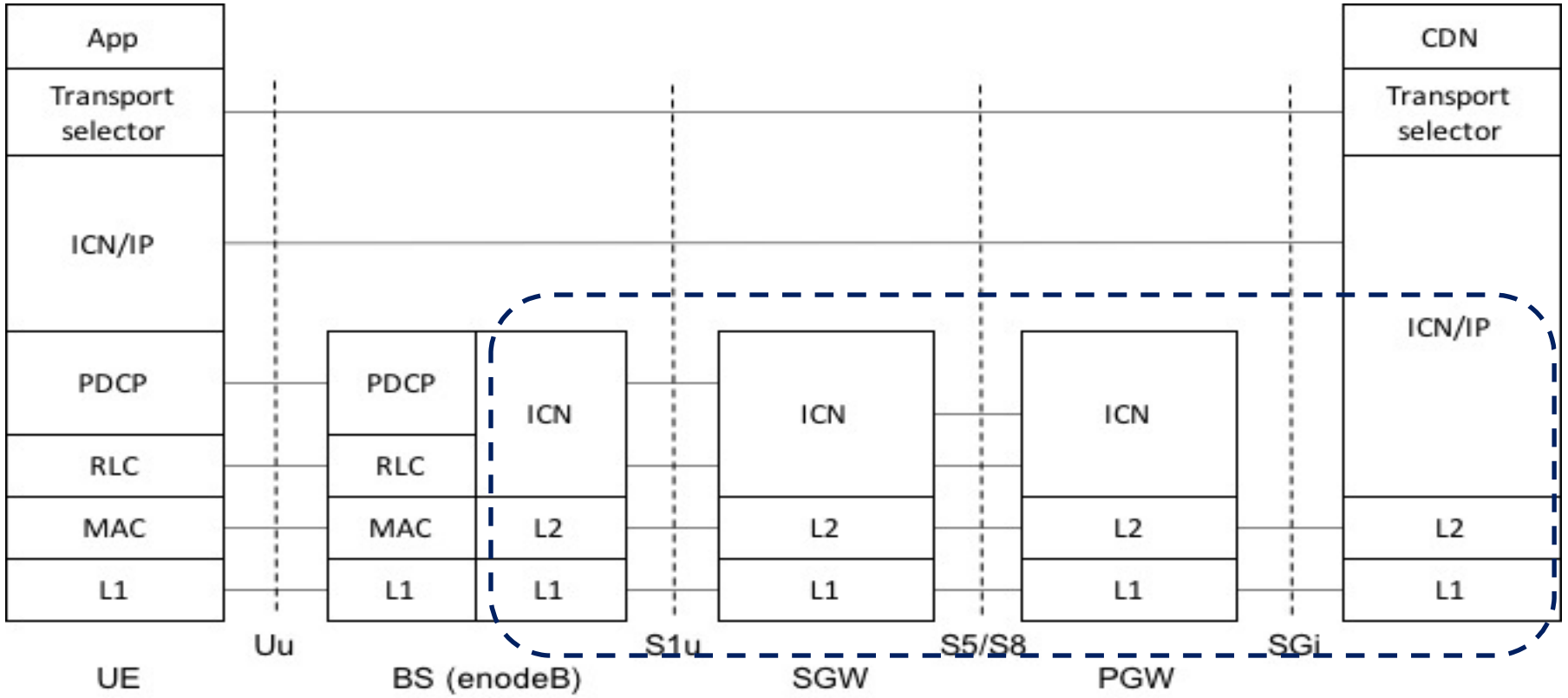


Fig. 9. Native ICN Deployment in eNodeB

eNodeB (ICN forwarder)

- UE preference and transport availability (IP, dual stack, native ICN)
- Application Programming Interface (API) from management systems

ICN Deployment in Transport



Routers and Mobile Gateways (ICN forwarders)

- Potentially removing GTP tunnel with native ICN
- Forwarding strategy and transport availability (IP, dual stack, native ICN)
- Application Programming Interface (API) from management systems

ICN Deployment in Mobile Gateways (PGW)

1. Insert ICN function at session management layer as additional functionality with IP stack.

2. When MME sends Create Session Request message to SGW or PGW, it contains Protocol Configuration Option Information Element (PCO IE) containing UE capabilities. We can use PCO IE to carry ICN related capabilities information from UE to PGW. This information is received from UE during the initial attach request in MME. Details of available TLV, which can be used for ICN are given in subsequent sections. UE can support either native IP, or ICN+IP, or native ICN. IP is referred to as both IPv4 and IPv6 protocols.

3. For ICN+IP capable UE, PGW assigns the UE both IP address and ICN identity. For ICN-capable UE it will provide only ICN attachment. For native IP-capable UE there is no change.

4. For ICN-capable UE attach procedures, PGW needs to have full ICN protocol stack functionalities. Typical ICN capabilities include functions such as content store (CS), Pending Interest Table (PIT), Forwarding Information Base (FIB) capabilities etc. If UE requests ICN in PCO IE, then PGW registers UE with ICN names. For ICN forwarding, PGW caches content locally using CS functionality.

5. Mobile gateways SGW, PGW will also need ICN forwarding and caching capability.

ICN Security Considerations

7 Key security domains

1. UE authentication and authorization
2. Radio or air interface security
3. Denial of service attacks on mobile gateway, services
4. Content positioning either in transport or servers
5. Content cache pollution attacks
6. Secure naming, routing, and forwarding
7. Application security

Existing/revised security spec TS33.310, TS33.320

ICN research/drafts

Further research is underway Security related encrypted content, mobile gateway capabilities for deep packet inspection (DPI), lawful intercept (LI), etc.

Next steps

1. Any additional questions?
2. Request for adopting as ICNRG working draft

BACKUP

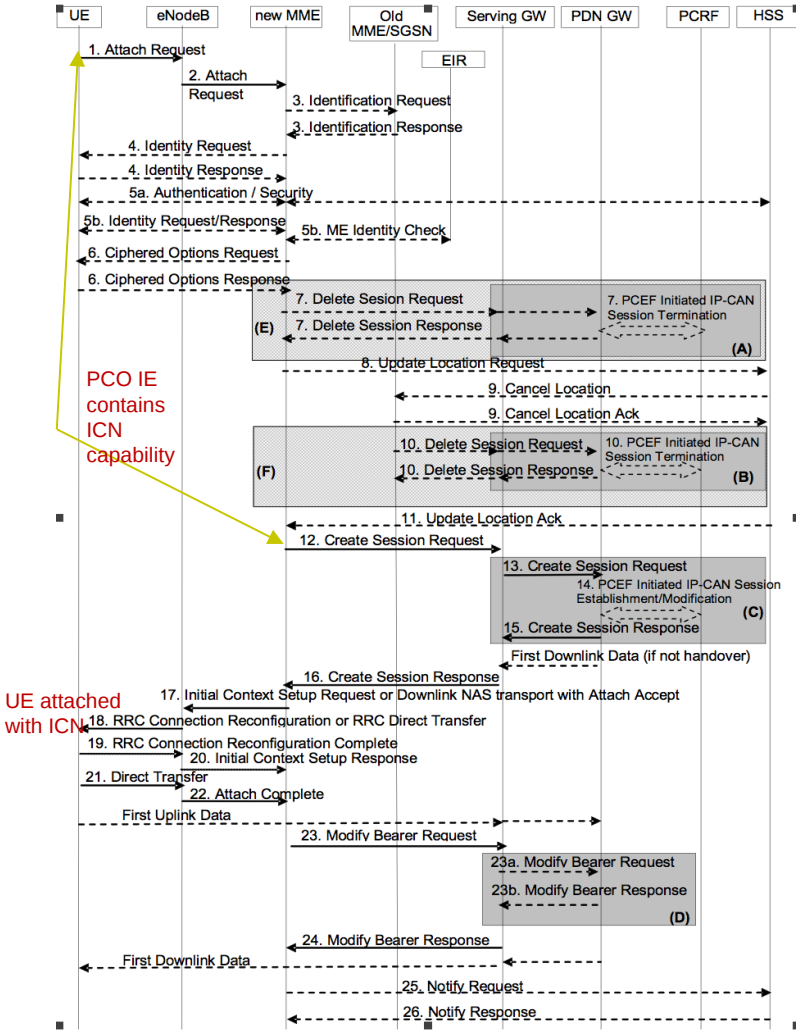
Deploying ICN in Mobile Gateway - Modified Attach Procedures

3GPP TS 23.401 V13.6.1 (2016-03) section 5.3.2.1 covers attach procedure. This require modification is step 12 to 22 (because of additional parameters ICN capability is populated in PCO IE TLV. Modified steps will support enhanced capabilities in PGW to support ICN attach in addition to normal IP attach procedures.

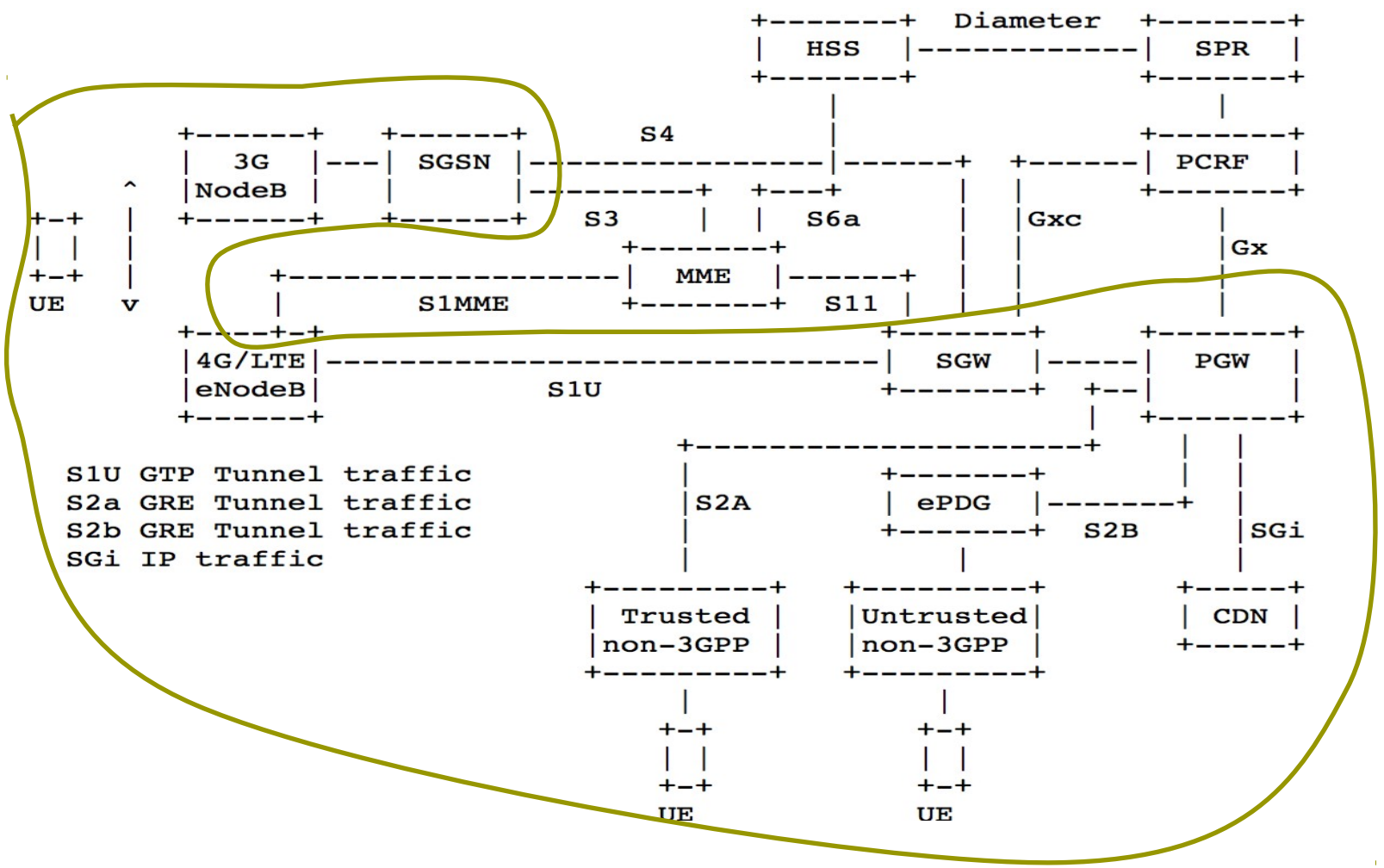
1. UE sends initial attach request. ICN capable device will send PCO IE field populated (Details provided in previous section) with ICN capability
2. BS (eNB) will forward attach request to MME. NAS signaling (step 3 to 6) will be performed to authenticate the UE. There is no modification for steps 7 to 11.

12. When attach request is successful, PGW/GGSN assigns identity to UE and creates session using PDN types. Type of attach is communicated to UE in step-16.

16. For UE requesting attach using PDN Type=IP, PGW will assign either IPv4 or IPv6 (Link local) in create session response (CSR). For PDN type = ICN, PGW will register UE with named identity. This will be used for creation of session and all context related function (billing, mediation, enhanced charring function/deep packet inspection, lawful intercept etc.) in function.



LTE Network Architecture – ICN User Plane Impact



LTE Signaling Messages

NAS Event Type	MME	HSS	SGW	PGW	PCRF
Attach	10	2	3	2	1
Additional default bearer	4	0	3	2	1
Dedicated bearer	2	0	2	2	1
Idle-to-connect transition	3	0	1	0	0
Connect-to-idle	3	0	1	0	0
X2-based handover	2	0	1	0	0
S1-based handover	8	0	3	0	0
Tracking area update	2	0	0	0	0
Total	34	2	14	6	3