Forwarding Label Support in CCN Protocol

(draft-ravi-icnrg-ccn-forwarding-label-02)

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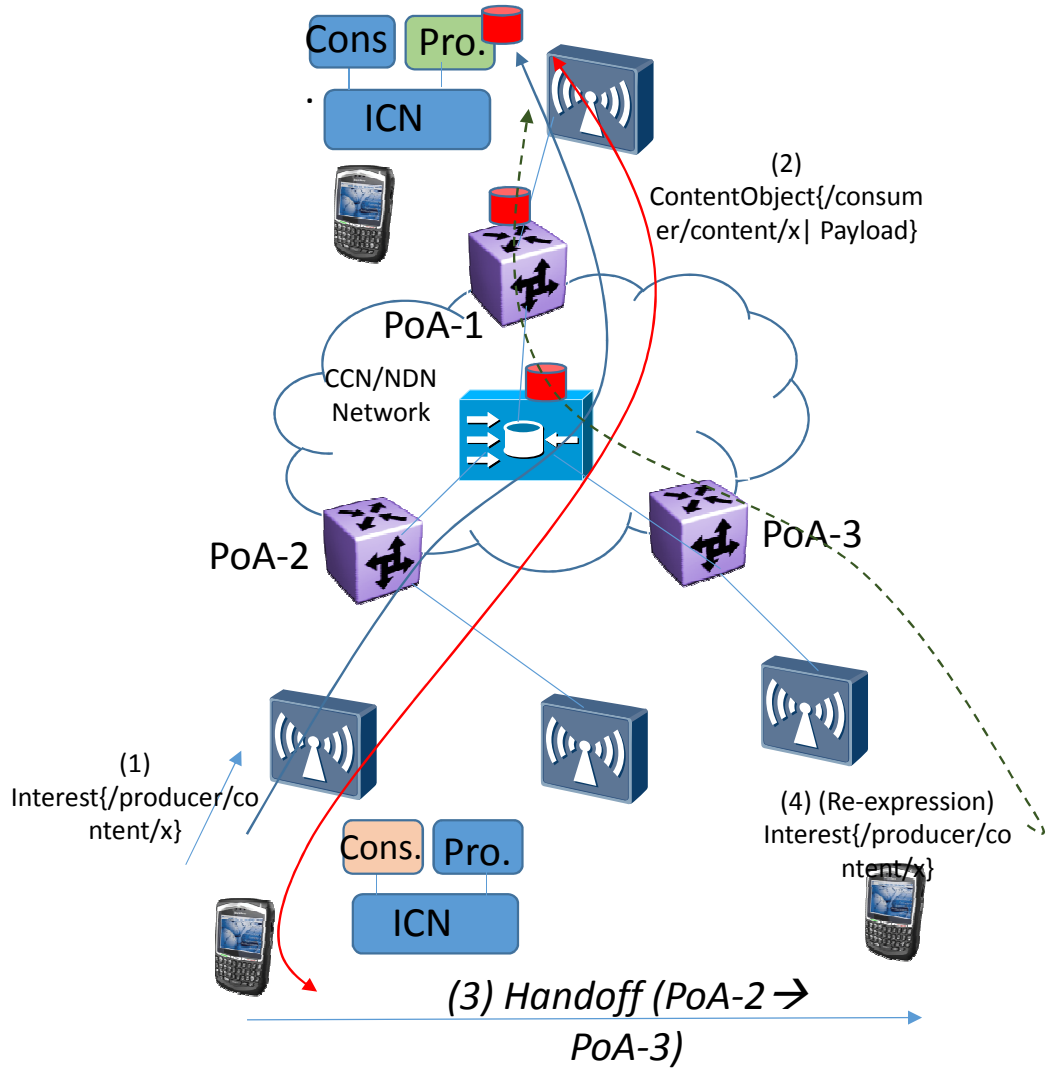
Draft Objective

- The rational for AI/NI construct in CCN is discussed in https://tools.ietf.org/html/draft-azgin-icnrg-ni-02
- This draft proposes a new protocol primitive called Forwarding Label Object for CCN
  - Its an optional field in the Interest message's header
- Can serve multiple purposes
  - Producer Mobility
  - Consumer Mobility (same idea applied to Data objects)
  - Routing Optimization
    - Off Path Caching
  - Routing Scalability
  - Service Affinity
    - For Conversational Flows
- The draft has been extended with a new use case of using FL for Consumer Mobility

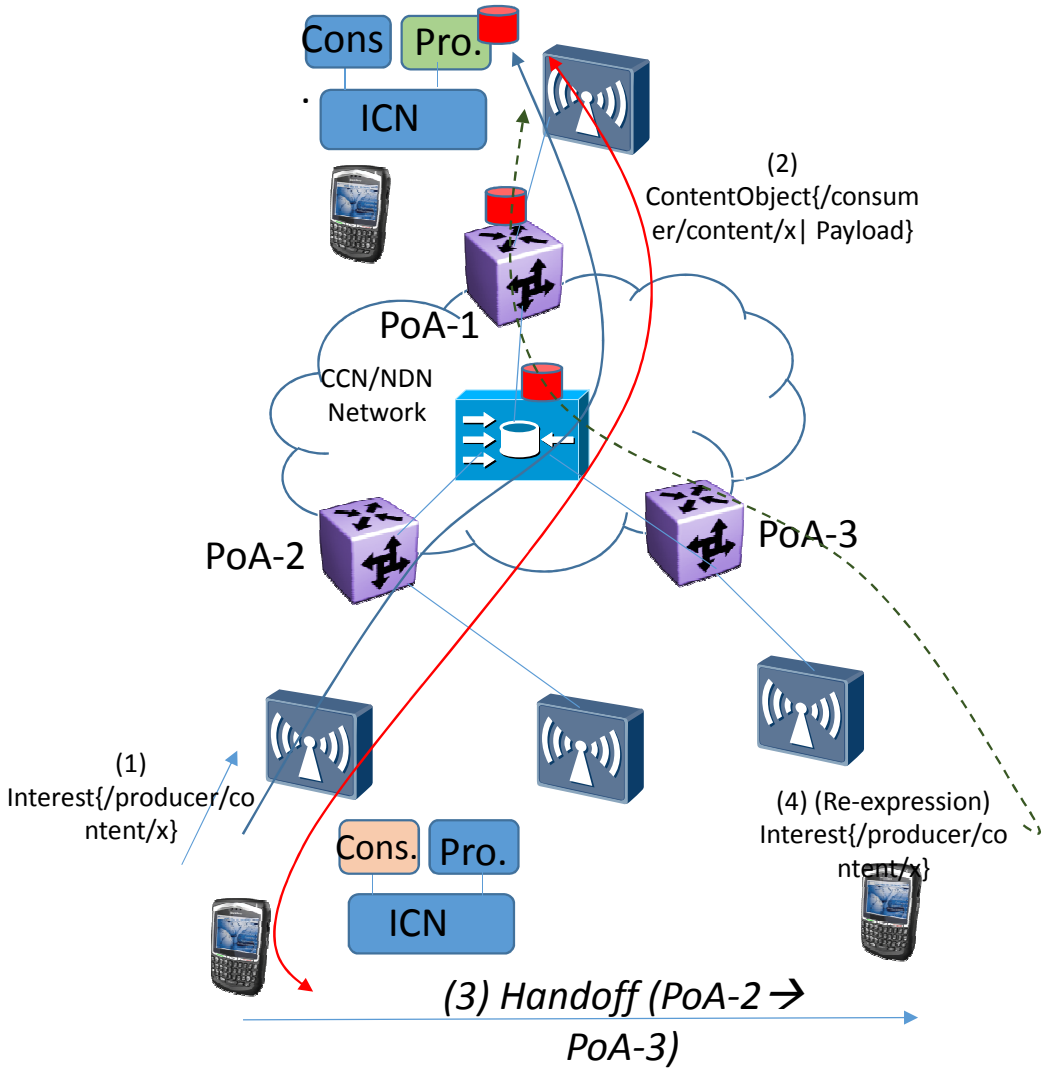
Current Handling of Consumer Mobility in NDN

- **Interest Re-expression** and **In-network Caching features** are used handle Consumer Mobility.
- **UE Application Solution** : When the consumer moves from one PoA to another.
  - The application Interests have to time out, and they re-expressed.
    - Current guideline to set Interest time outs to order of seconds
    - Inefficient for applications with strict time deadlines.
    - If application chooses to be proactive, Interests can be blocked if application defined timeouts are not permitted, which has implication on router design.
  - Better approach is UE's CCN layer, can also re-express (which requires notification from the MAC layer). Requires to find all the affected Interest mapping to the face.



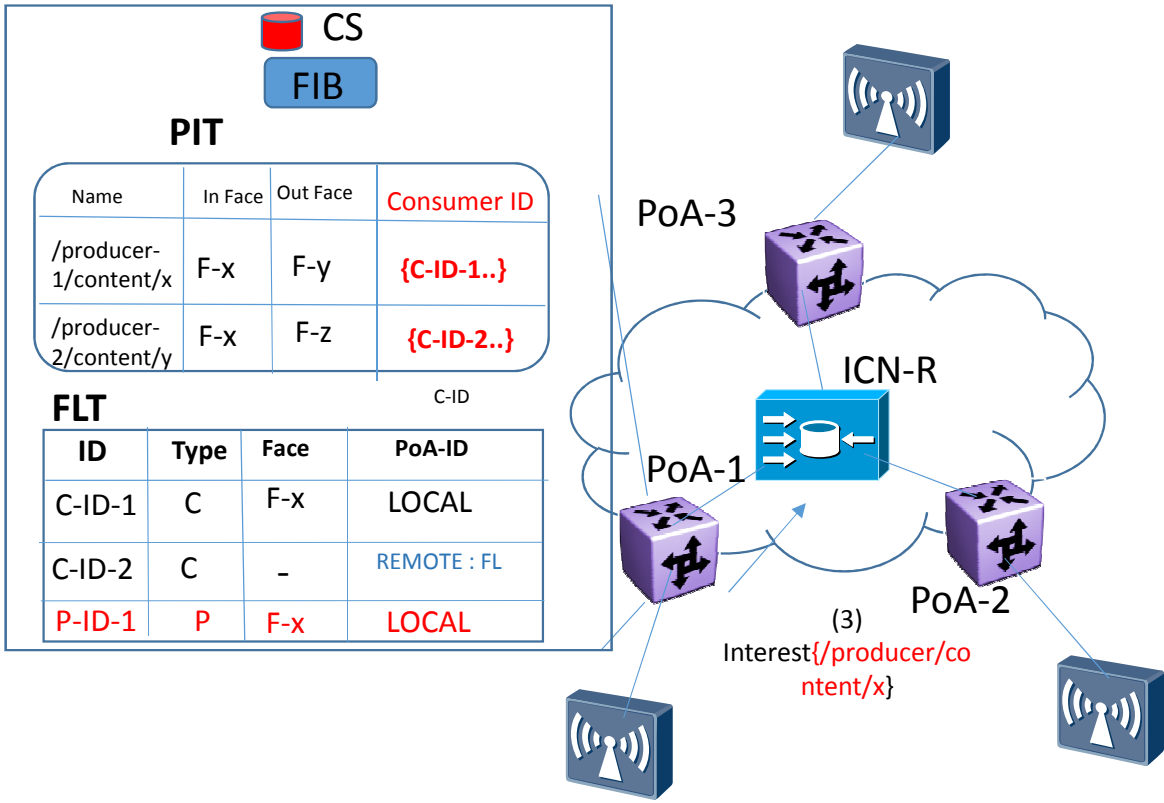
Current Handling of Consumer Mobility in NDN

- **UE CCN level Solution** : After re-expression, in the best case the consumer can get the content from the first intersection router between the old_PoA-to-Producer path and new_PoA to-Producer path.
  - Depends on in-network Caching strategies and content popularity
  - Best case scenario is the same node, if the old and new APs connects to the same PoA.
  - The worst case scenario is that, it has to fetch the content from the producer, which could be multiple domains away too.
- **Seamless mobility requirements**
  - Typical LTE mobility aims for ~100ms of session disruption
- The above uncertainties could make UE driven consumer mobility inefficient and unpredictable.
- The proposed idea tries to achieve this as a network service, by using the idea of forwarding-label to content objects.



Using Forwarding Labels for Consumer Mobility

- **We re-use the Forwarding Label cache Table [1] (FLT) to map the Consumer-ID to the local transport face and a forwarding label.**
  - FLT was proposed in [1] for producer mobility, the same table can be used for consumer mobility too.
  - Consumer-ID and Producer-ID can be the same, if mobility is handled at the device level.
  - The status stores the state of the device, as being Attached or Moved with a new FL.
- **The Interests from the consumer should include the consumer-ID.**
  - This has only local significance, i.e. it is not forwarded beyond the PoA.
- **The PIT is modified to store the set of C-IDs requesting the content.**



[1] Aytac Azgin, Ravi Ravindran, G.Q.Wang, "Seamless Mobility as a Service in Information Centric Networks", 5G/ICN Workshop, ACM ICN Sigcomm, 2016, http://conferences2.sigcomm.org/acm-icn/2016/proceedings/p243-azgin.pdf

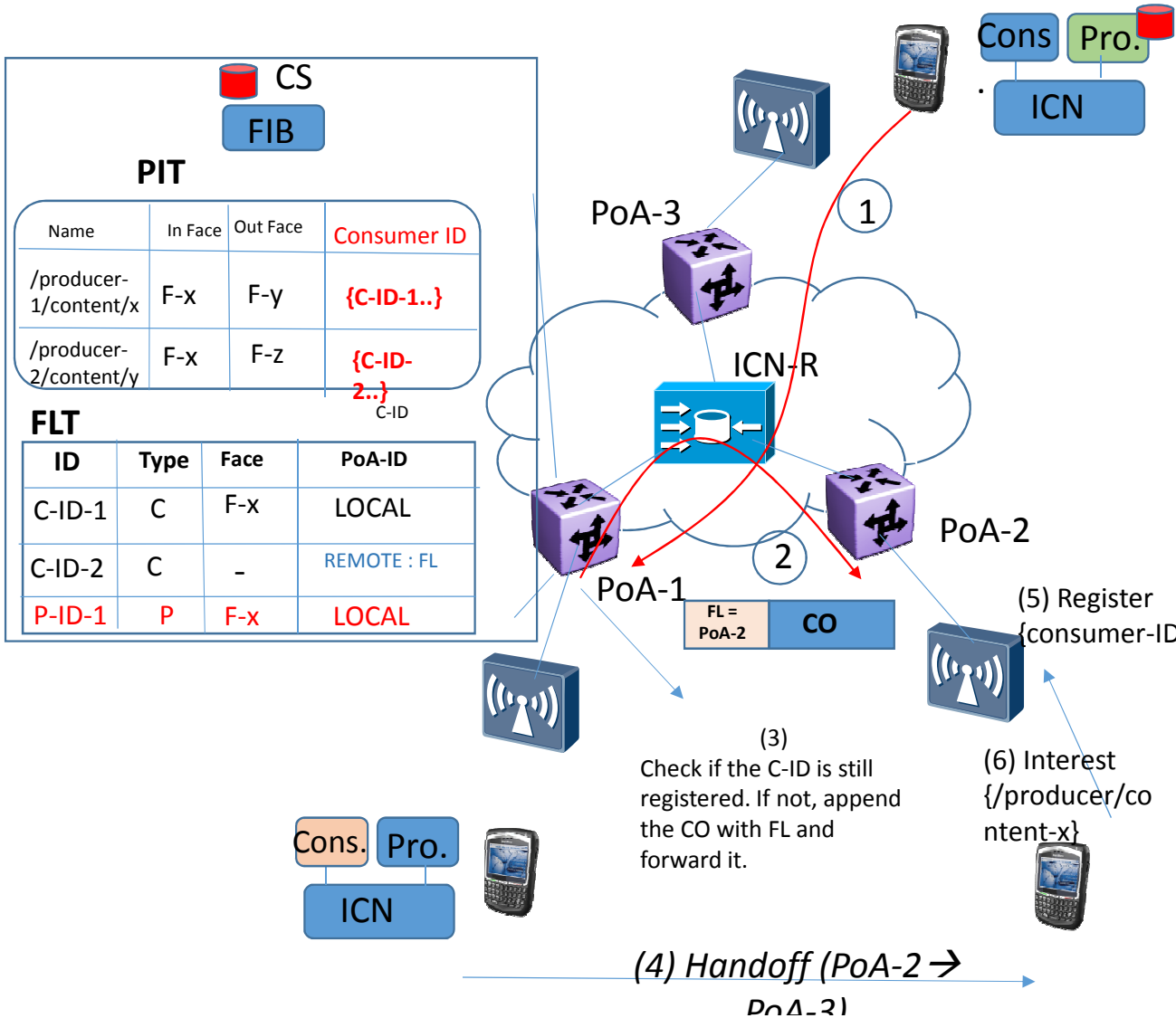
Using Forwarding Labels for Consumer Mobility

UE Signaling

- Assuming network assisted mobility, the UE will signal the movement by identifying the Consumer ID and the new PoA it is moving to.
- The FL can also be set of candidate PoAs, in this case the received CO packets can be unicast to different PoAs.
- The FLT table is updated with the new FL information.

Handling Content Objects (CO)

- The Name in the CO is matched against the PIT, then the status of the corresponding C-IDs is checked in the FLT.
- If they are locally attached, the CO is locally forwarded, else the FL is attached to the CO and forwarded to the new POA.
- The C-ID is also appended to these CO, for identification at the new POA.



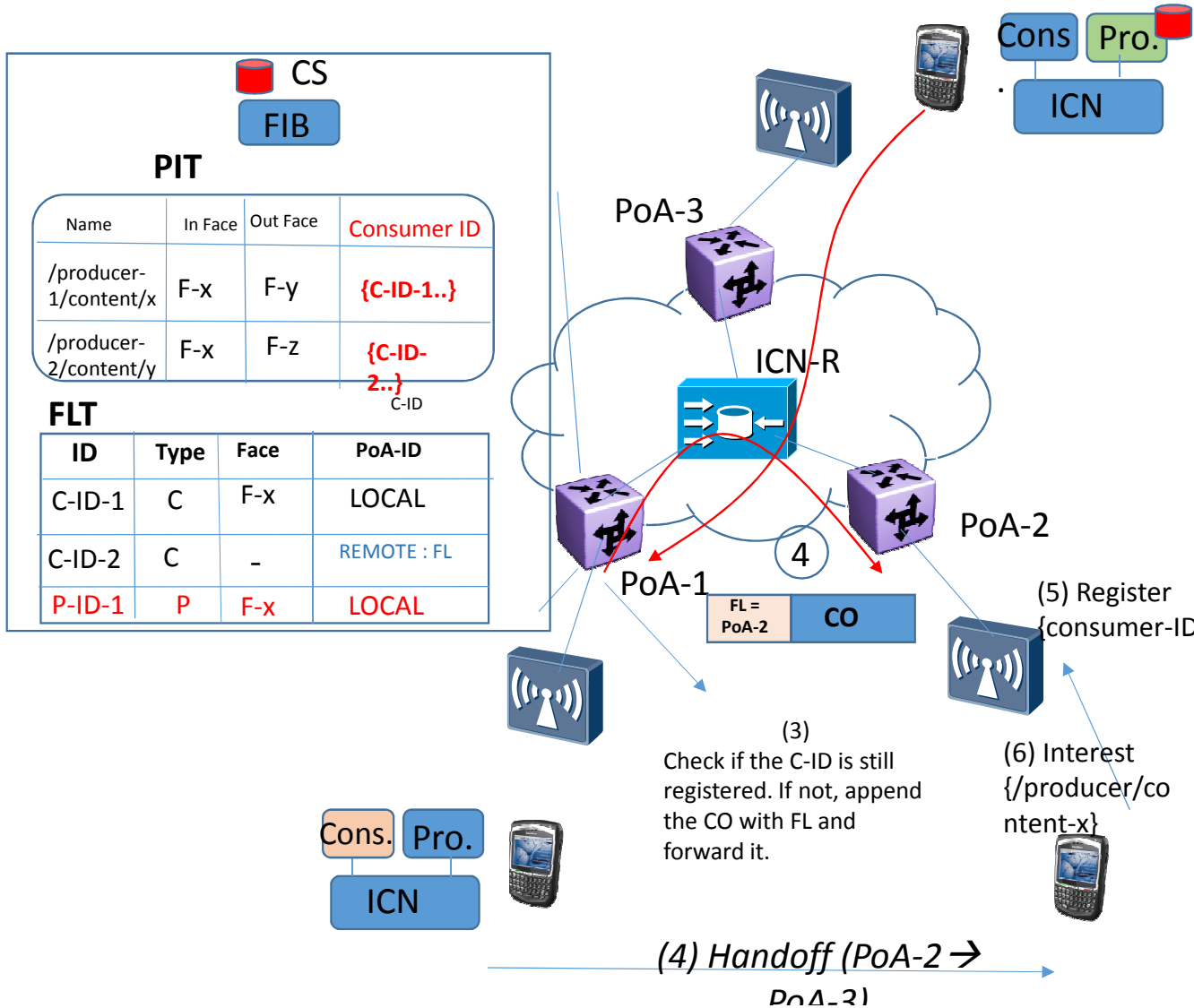
Using Forwarding Labels for Consumer Mobility

Network Handling of CO

- These POA forwarded COs are marked to be treated differently than the regular CO
- The ICN routers use the FL in the CO to forward the packets to the new POA
- At the new POA, the COs can be pushed to the UE, or cached to be pulled.

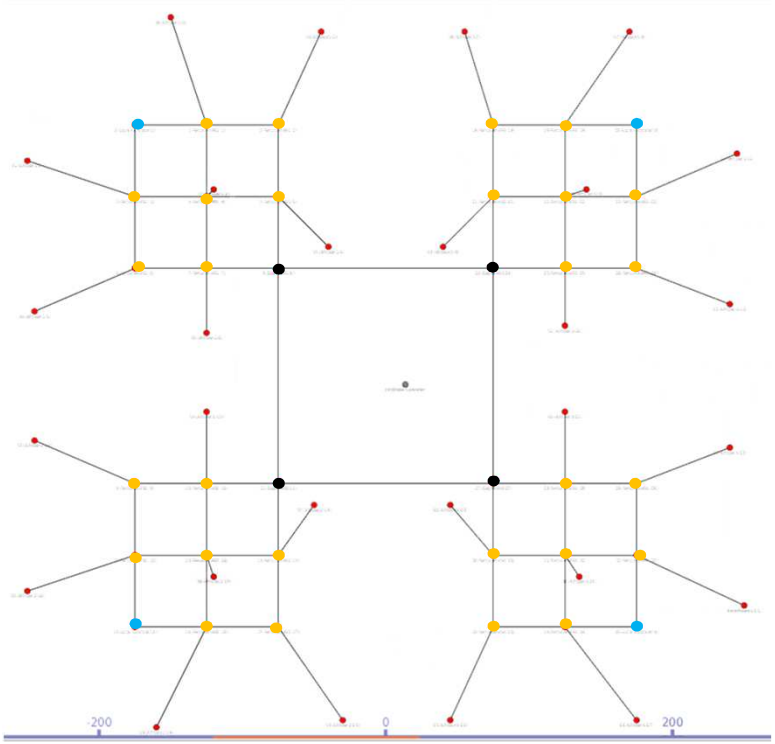
Caching Implications

- The CO will not be cached in the path from the intersection router to the old POA.
- It can be cached in the path segment between the intersection router and the new POA



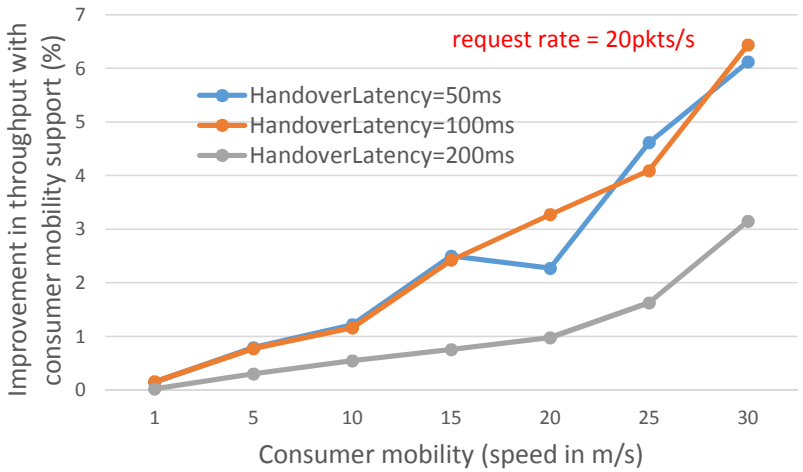
Simulation Setup

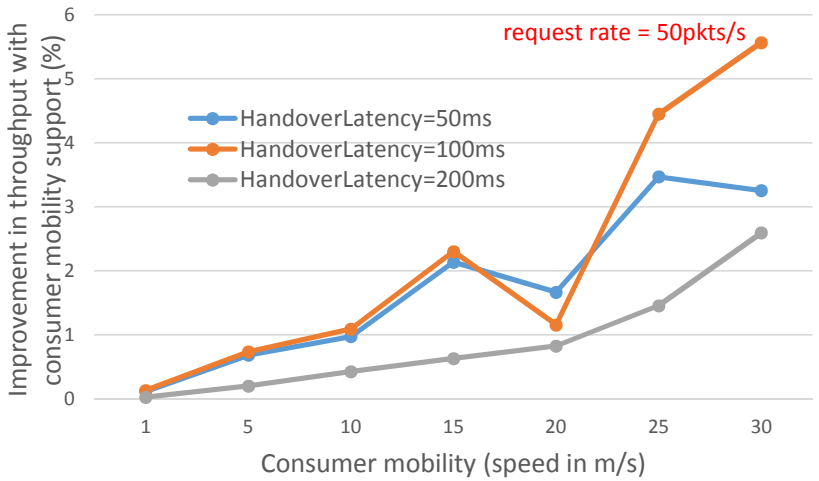
- We used ndnSIM to simulate the network topology, which is a grid-based network topology
  - Each node on the grid represents an ICN Router that functions as Service Point (yellow), Controllers (blue) for producer mobility.
  - Nodes outside grid (red) represent Access Points
- Consumer and Producer are placed in different regions
- Consumer speed is varied from 1m/s to 30m/s
- Handover latencies are varied from 50ms to 200ms
- Constant bit rate traffic is used, with Consumer's request rate is varied between 20pkts/s to 50pkts/s
- We measured the successfully delivered packet rate vs. request rate from the consumer side and its speed
- The default consumer mobility settings were not changed, and we compare results in terms of throughput.



Network topology

Simulation Results at different loads and handover latencies

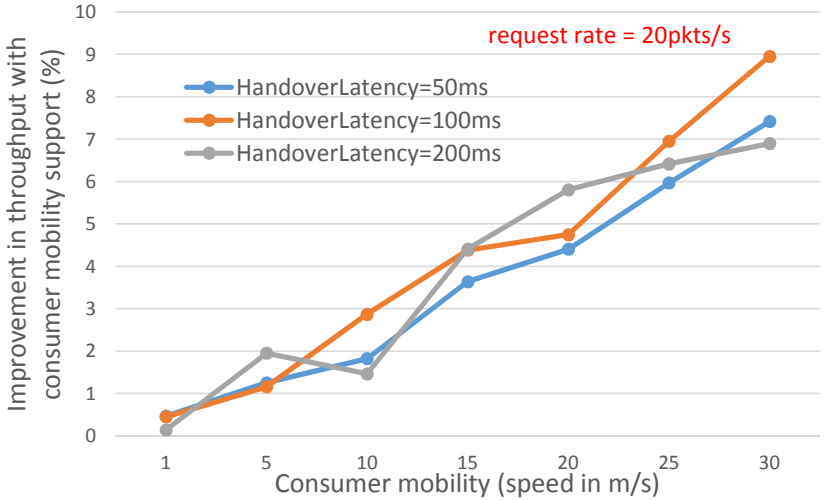


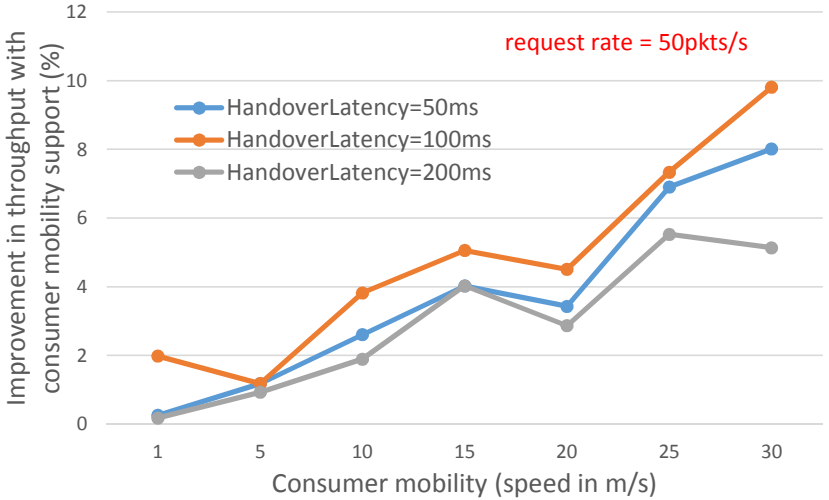


- The main gain from the consumer mobility support architecture is to be able to receive data as soon it connects to the new PoA, as otherwise consumer may need to wait one RTT to start receiving data packets.
- Improvement may decrease at the highest handover latency (which would depend on the scenario), because the impact of lost requests during handover on the overall throughput at the consumer can increase.
- With 5G systems and beyond that aims to minimize handover latencies, the performance difference will be more severe.

Simulation Results at different loads and handover latencies

We doubled the link latencies to increase the RTT time in-between end hosts





- Increasing RTT at the same request rate results in higher number of pending Interests at the access points or service routers.
- Such a case can degrade the performance as more packets would be lost during a handover, and needs to be recovered through retransmissions.
- Our solution limits the impact of those by delivering such Data packets to the new point of attachment.

Thank you