

# Bridging the ICN Deployment Gap with IPoC

Susmit Shannigrahi, Colorado State Univ.

Chengyu Fan, Colorado State Univ.

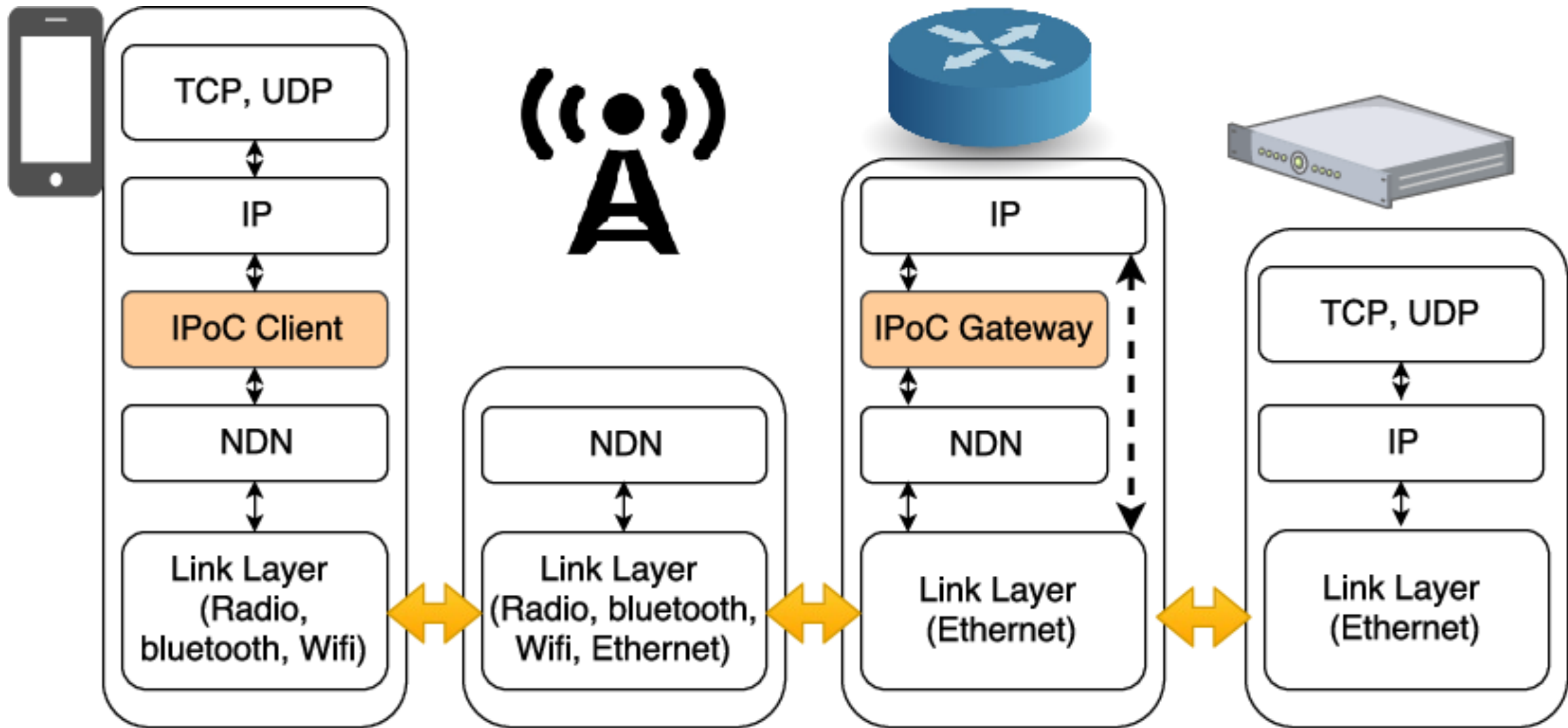
Greg White, CableLabs

# Background

- ICN seems attractive for mobile networking
  - Elegant consumer mobility via stateful forwarding
  - Multipath connectivity managed by the mobile device
  - In-network caching and processing
- How do we get there?
  - Network slicing? – and run two networks in parallel?
  - ICN over IP? – and lose the benefits above?

# Concept

- Explore the idea of using ICN as THE forwarding plane for 5G
- **Support ALL existing IP services** via an “IP over ICN” protocol – replacing LTE-EPC (GTP Tunnels) for IP Mobility
- Enable deployment of native ICN applications, preserving the benefits



# IP over ICN (IPoC) Goals

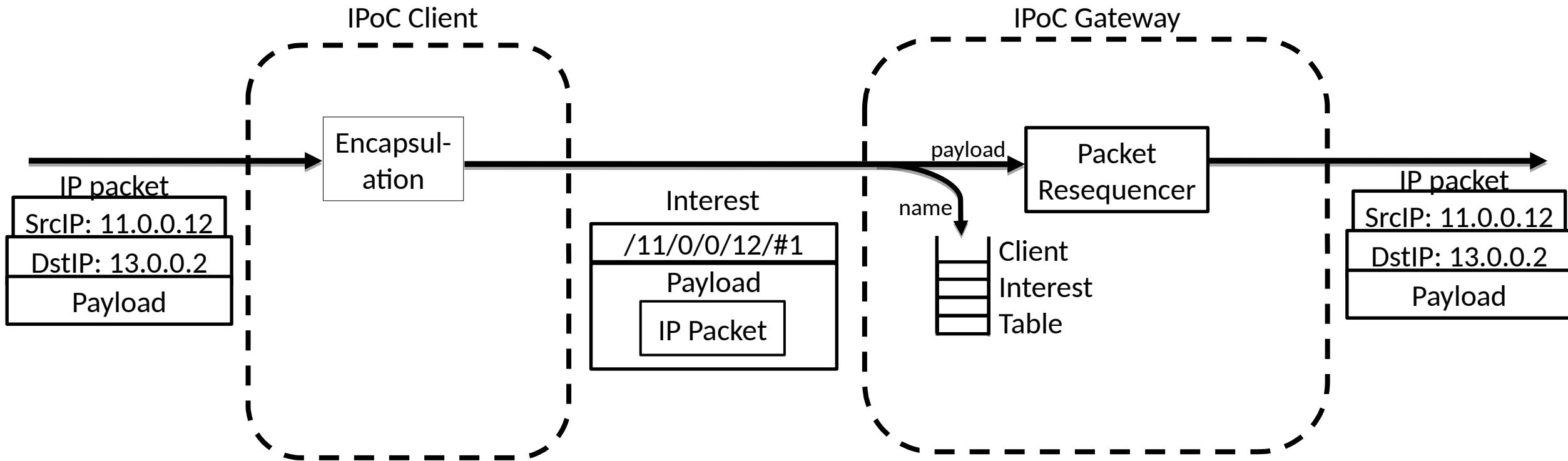
- Support all existing IP applications & transports without modification
  - Incl. TCP, UDP, SCTP, DCTCP, QUIC, BBR, etc.
  - ...maybe not IP multicast.
- No change to IP stacks
- Leverage consumer mobility of ICN
- Support multipath connectivity
- High performance
- Low overhead
- Be a compelling replacement for EPC



# Leverage consumer mobility

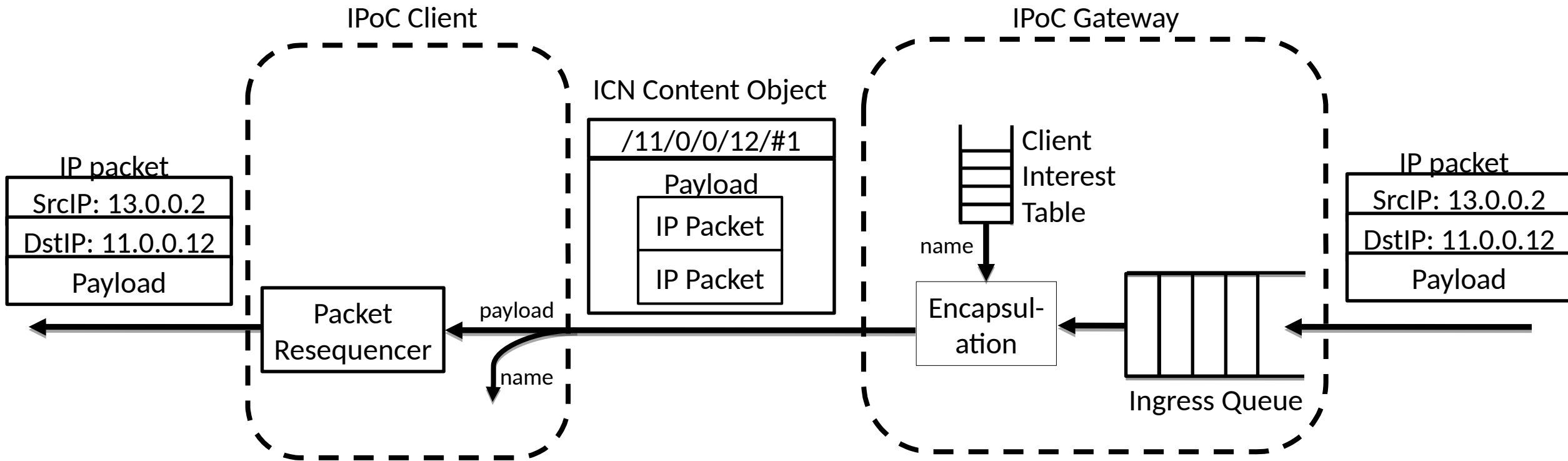
- IPoC Client only sends Interest messages
  - “upstream” IP packets carried as Interest payloads
- IPoC Gateway only sends Content Objects
  - Containing “downstream” IP packets as payloads

# “Upstream” (UE->Network) Packet Flow





# “Downstream” (Network->UE) Packet Flow



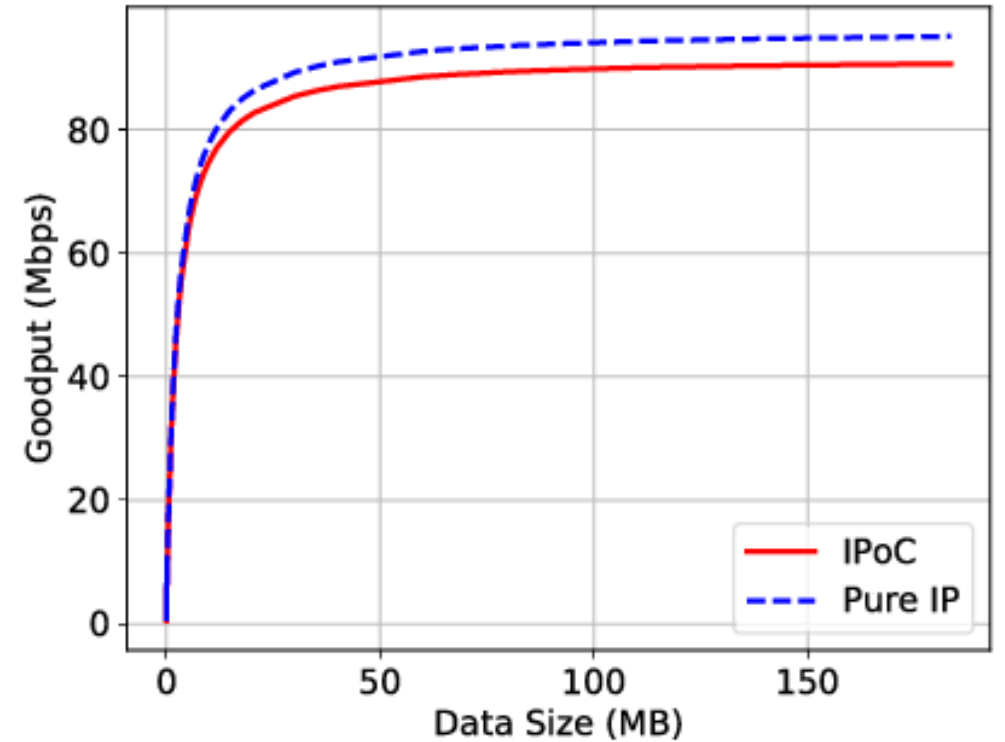
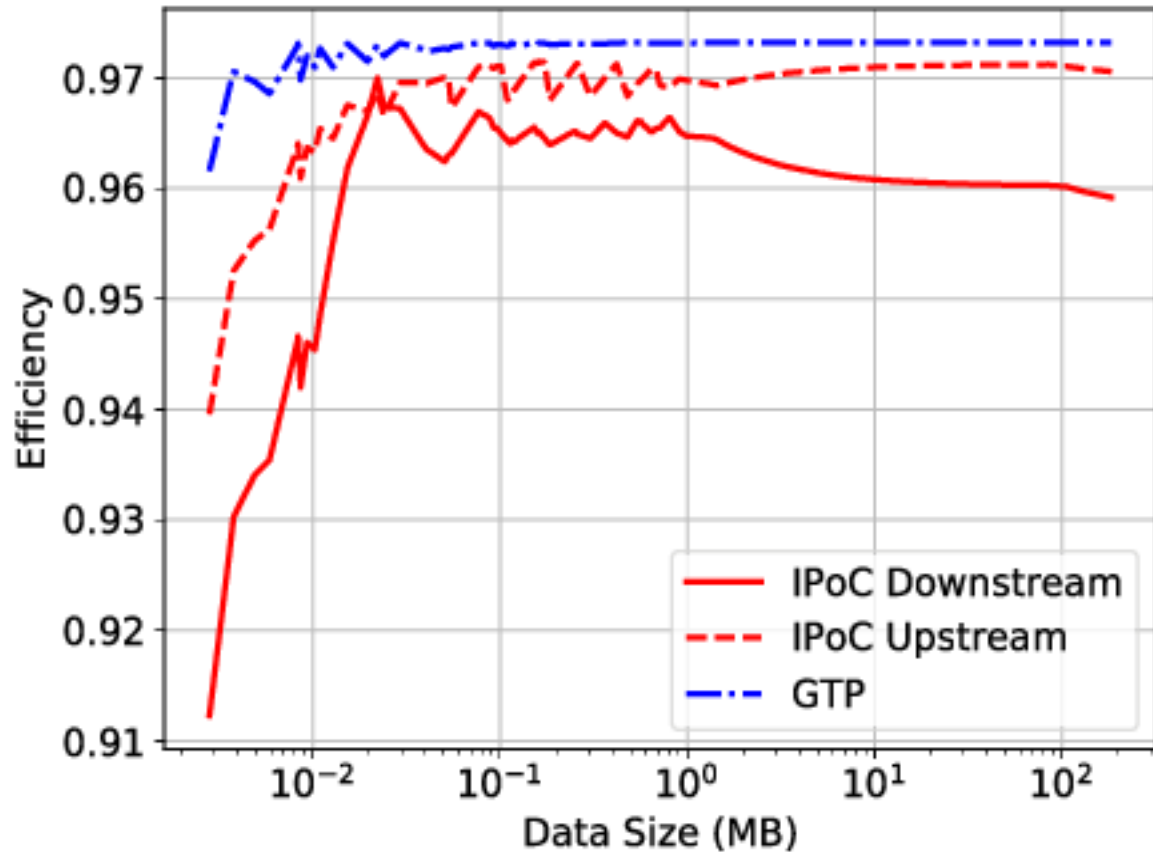
# IPoC Naming Convention

- `ndn:/ipoc/<hex_ipaddr>/<b64_seq>`
- `hex_ipaddr`: Client IP address
- `b64_seq`: Interest Sequence Number
  - base64-encoded, monotonically increasing (with rollover)

# Managing In-flight Count and Flow balance

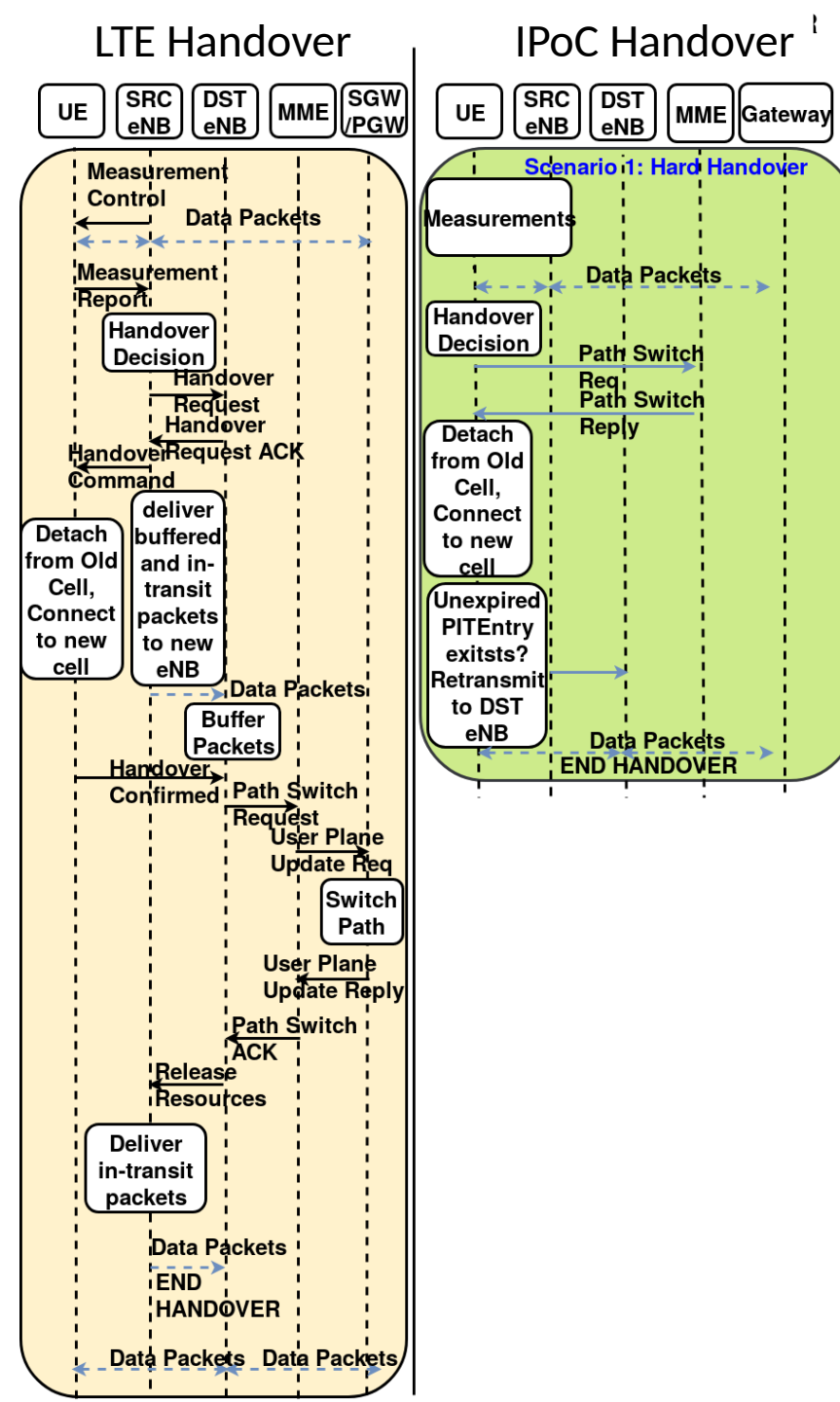
- Gateway sends IDR to the client with each content
  - Interest Deficit Report included in Content Object
  - Allowed IDR values: -1, 0, 1
  - Client adds IDR value to its Interest Deficit Count

# Evaluation - Efficiency and Throughput



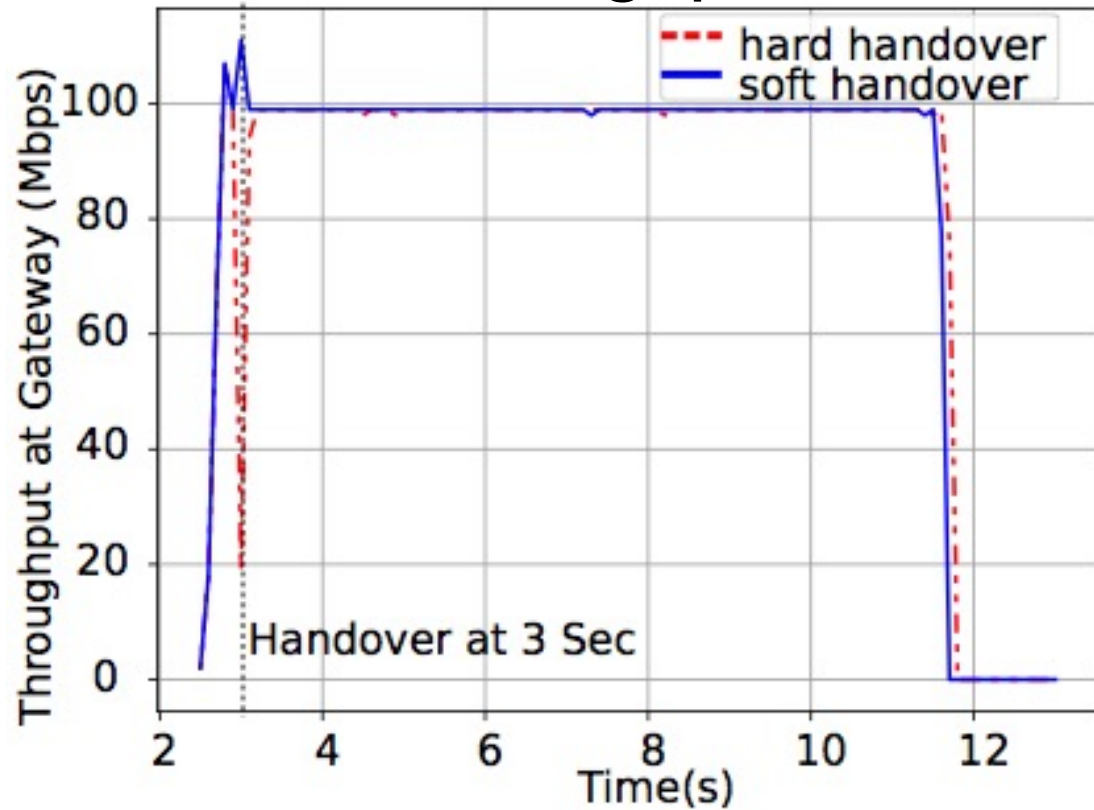
# Reciprocal Benefits for 5G networks - LTE Handover vs. IPoC Handover

- IPoC significantly simplifies handover compared to LTE-EPC
- UE simply detaches from old link, establishes new link, and resends unexpired PIT entries (without payload).
- No handover-specific functions in GW, eNodeB/gNodeB, or network routers
- Soft handover & multipath connectivity are simple

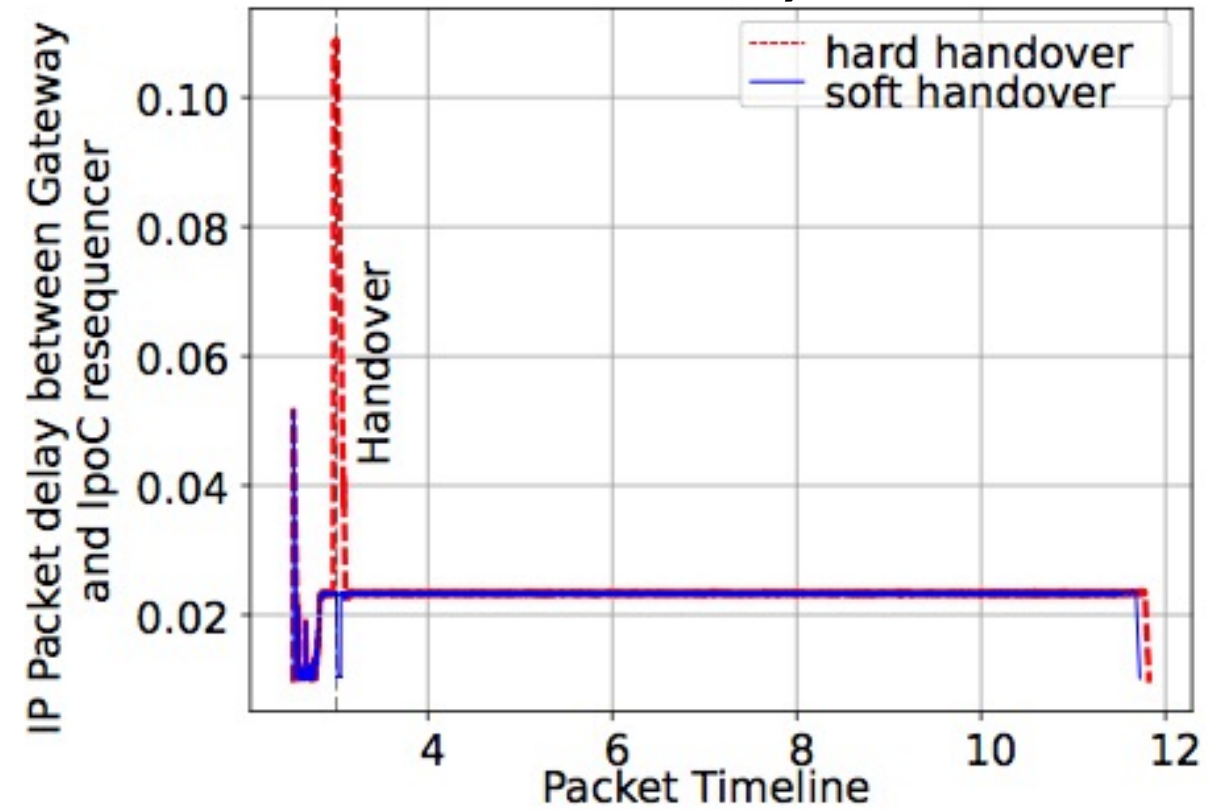


# Hard vs Soft Handover Simulation

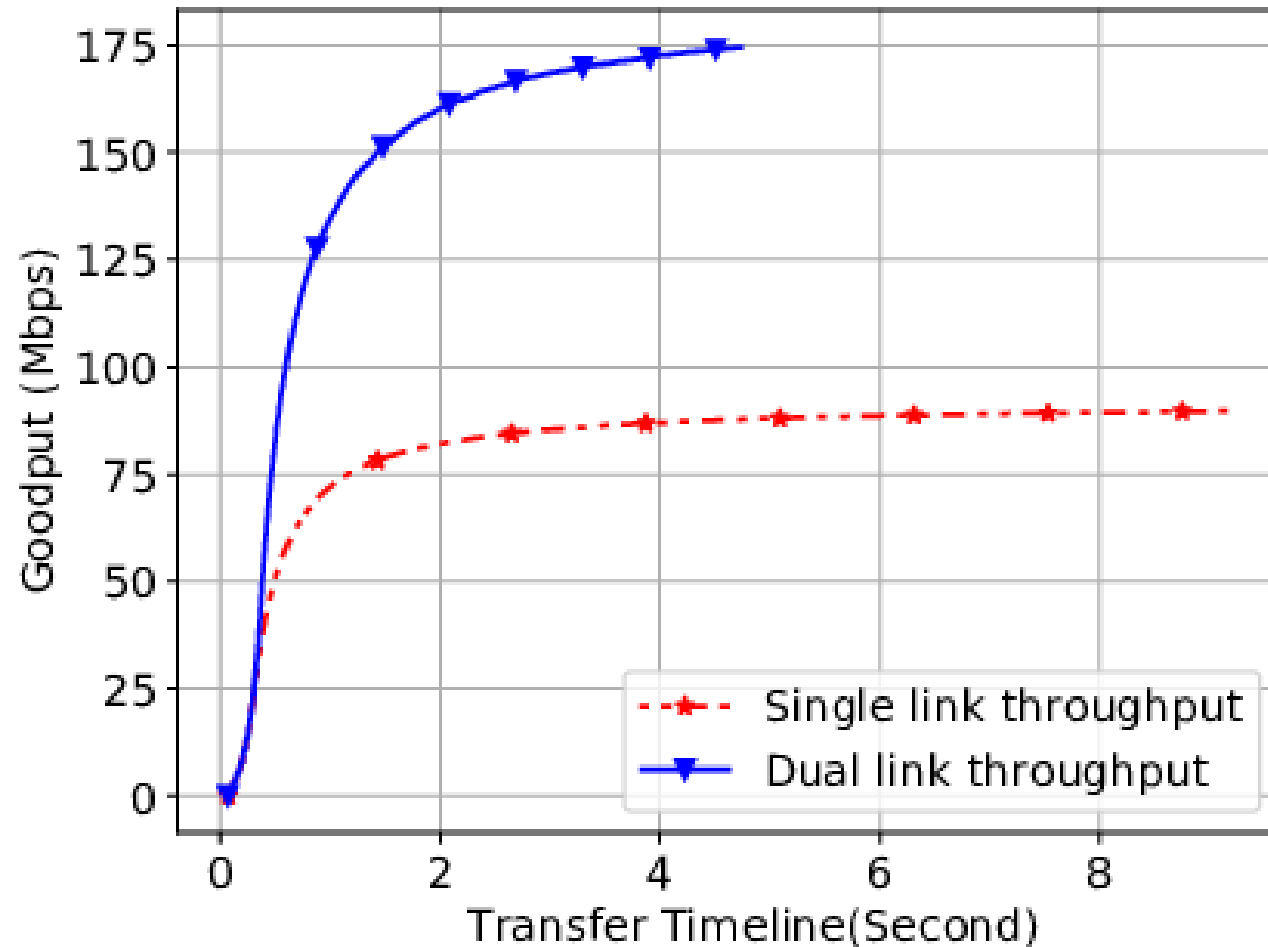
## Throughput



## Delay



# Dual link – 5G/5G or 5G/WiFi



# Implementations and future plans

- ndnSim implementation (ca. 2017)
  - Published at 2018 SIGCOMM NEAT
  - Soon to be available in github
  - Possible NDN testbed deployment?



Questions and Comments?

# “Upstream” IP packet handling

- Client: Upon receipt of one or more IP packets from the local stack:
  - Send an Interest message
    - Name formed by client’s IP address and next sequence number
    - Body contains entire IP packet(s)
- Gateway: Upon receipt of an Interest message
  - De-encapsulate IP packet(s) and add to resequencer for forwarding to IP network
    - Resequencer ensures in-order delivery
  - Add Sequence Number to the “Client Interest Table”

# Client Interest Table (CIT)

- The CIT is a FIFO queue maintained by the gateway
- CIT contains received Interest Sequence Number and Arrival Time tuples
- One CIT per active client IP address

# “Downstream” IP packet handling

- Gateway:
  - Arriving IP packets are queued on a per-client-IP basis\*
  - Queues are serviced in a round-robin manner
  - Queue blocks when its CIT is empty
  - Packet(s) are dequeued to form a Content Object
  - CIT entry is dequeued to form CO name
  - CO includes a CO Sequence Number (monotonically increasing, with rollover)
    - CO Sequence Number space is independent of Interest Sequence Number space
- Client: Upon receipt of a Content Object
  - De-encapsulate IP packet(s) and add to resequencer for delivery to IP stack

\* more sophisticated queuing, e.g. AQM/L4S could also be used