Offline Content Access with NDN and D2D Communication

Preechai Mekbungwan[1], Adisorn Lertsinsrubtavee[1], Kanchana Kanchanasut[1], Marcelo Dias de Amorim[2] and Serge Fdida[2]

[1]intERLab, Asian Institute of Technology, Thailand

[2]LIP6, Sorbonne University, France

ICNRG, IETF 122

17 March 2025, Bangkok, Thailand

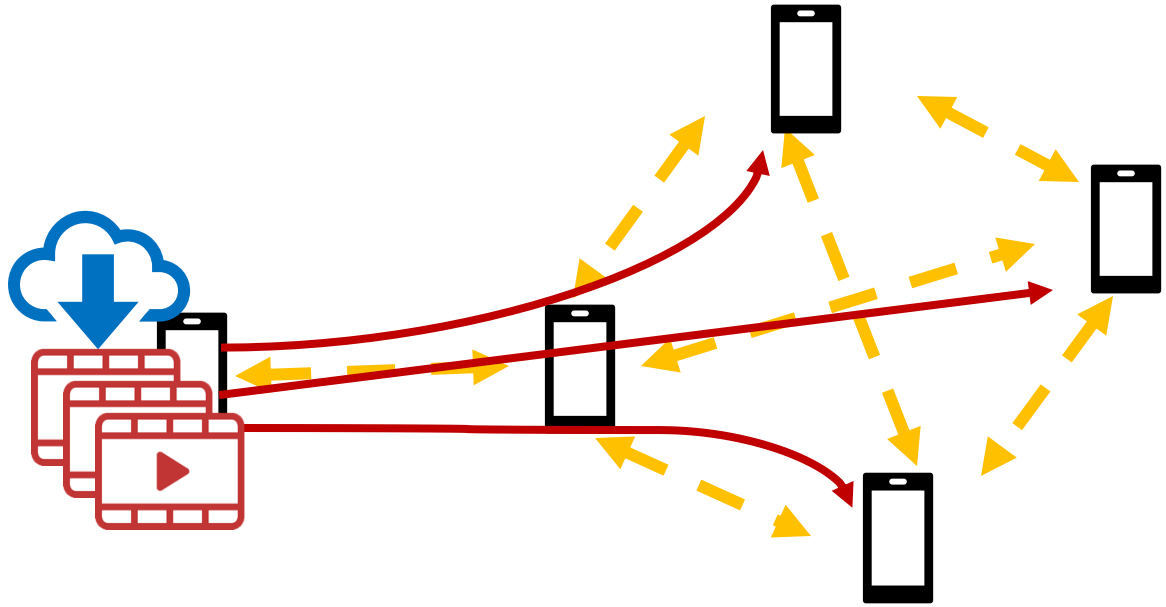
Unaffordable Internet access

- Internet access is often expensive particularly for underprivileged communities
- Many rural areas lack internet coverage

These people lack the opportunity to access valuable online resources.

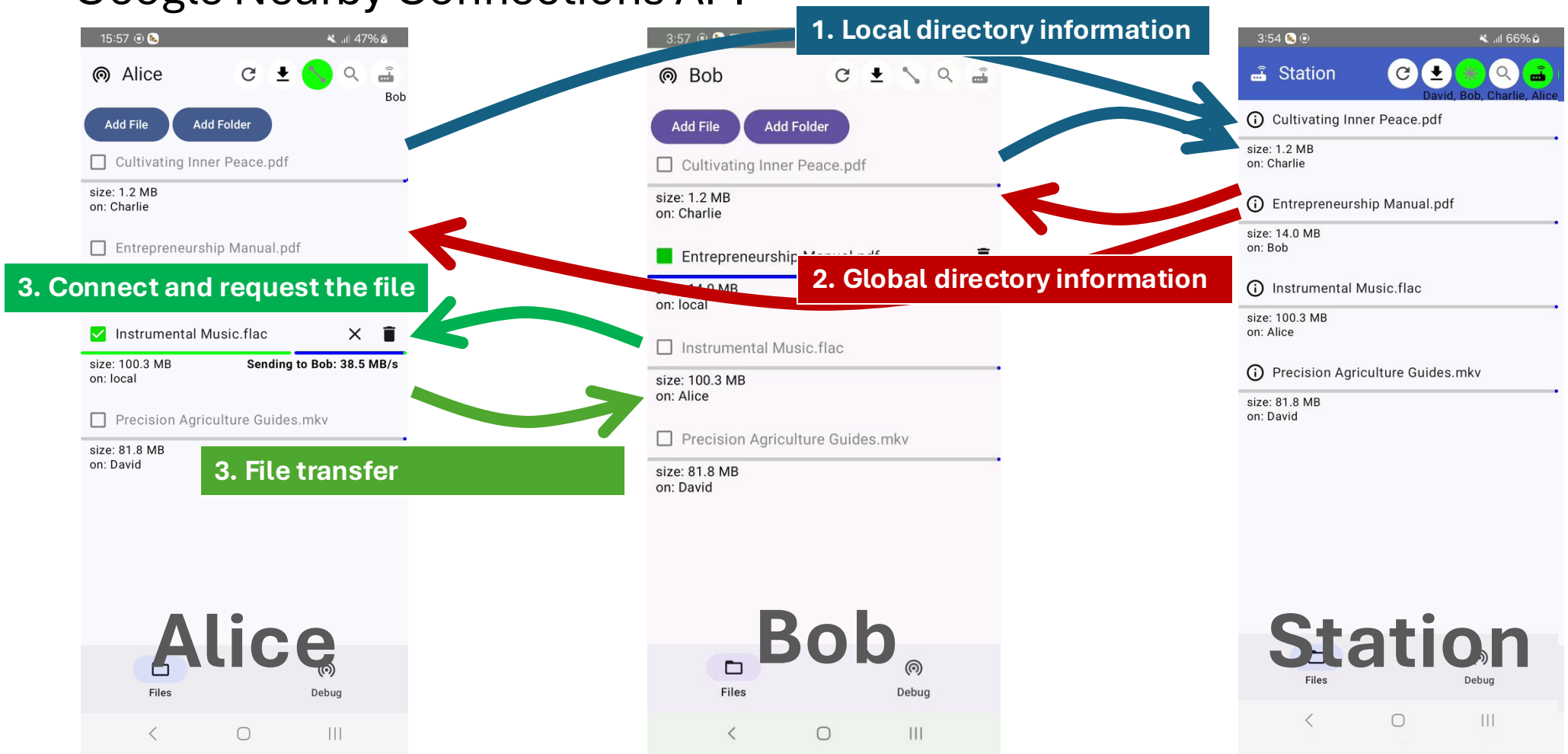
D2D Offline Content Access

- Device-to-Device communications
- User pre-download content for subsequent viewing and sharing
- The content is stored on the device and can be access by devices in the area using D2D



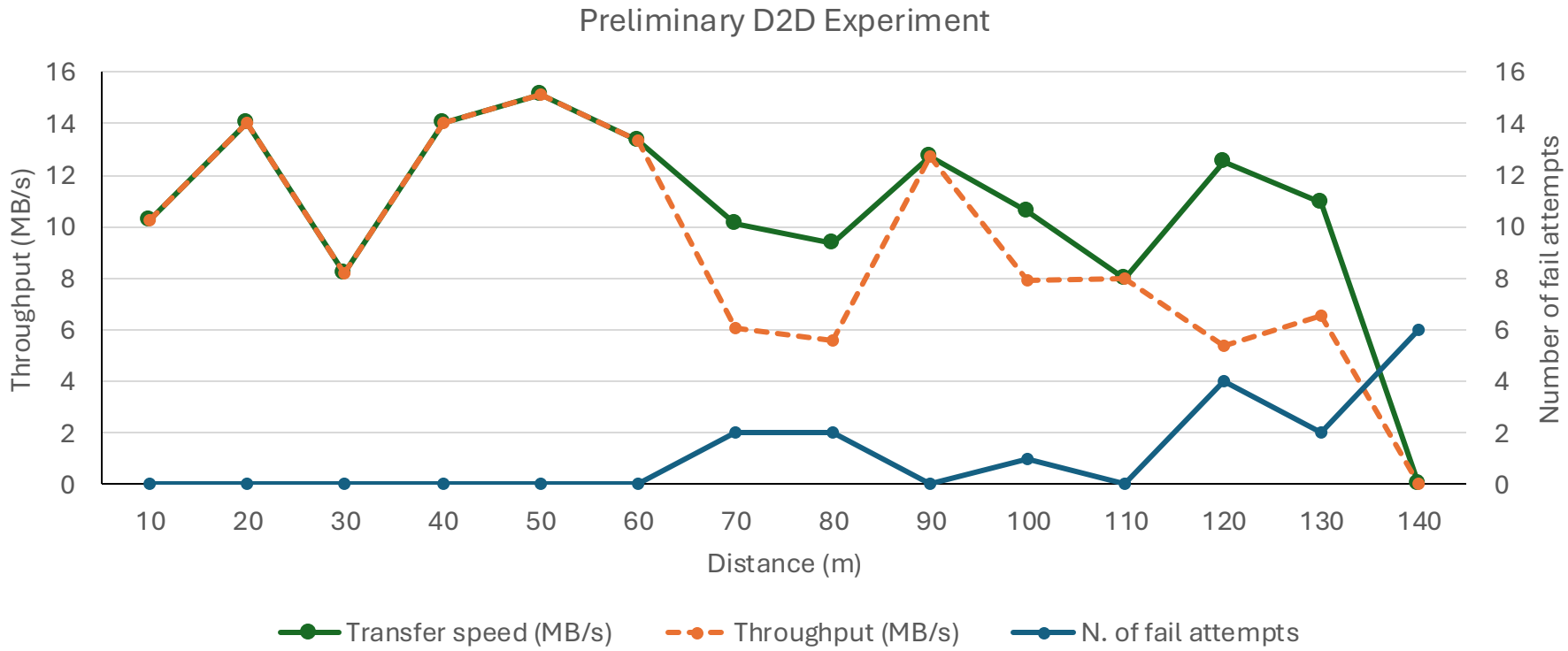
D2D Prototype

- File transfer application on Android devices
- Google Nearby Connections API



Preliminary Experiment

- Single-hop file transfer experiment:
  - Maximum throughput: 15MB/s.
  - Distance: up to 130m.



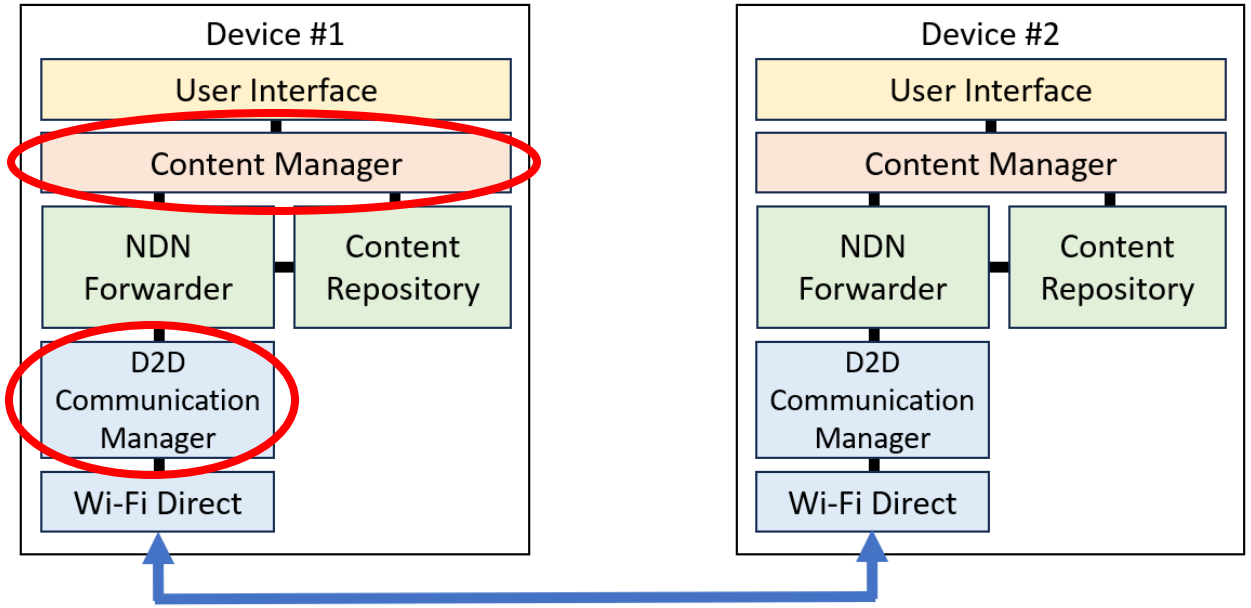
Named Data Networking over D2D

- NDN decouples content from its physical location.
  - Allowing routers to *forward requests based on content availability*, not location.
  - Enabling *multi-hop content discovery and retrieval*
- NDN can be used for content management
  - *Name-based forwarding* can used as content discovery service, allowing content to be located by name regardless where it is located
  - *In-network caching mechanism* allowed content to be cached which significantly improve performance when content is cached closer to the requesting devices.

Challenges implementing NDN on D2D

Challenges	Our solutions
• D2D connections are opportunistic but NDN does *not handle unreliable connection*.	• Utilize *long-lifetime Interest packets* to maintain their validity when connections are not available
• NDN does *not natively support pushing mechanism*. A Data object without a matching PIT record will be dropped.	• Introduce *Persistent PIT records* which will be kept even a matching Data is received.
• The *discovery and connection setup* procedures are required in D2D.	• Introduce *D2D communication manager* between NDN Forwarder and D2D layer to manage D2D connection procedures.
• There are *no standardized APIs* across diverse D2D technologies and platforms.	• Focus on Android devices and use *Google Nearby Connections API* for D2D.
• The D2D devices often have *limited resources*.	• Use *LRU caching* and prioritizing the storage for user-preferred content.

NDN over D2D Architecture



Mechanisms:

- Long-lifetime Interest
  - For opportunistic connections
- Persistent PIT records
  - For content pushing

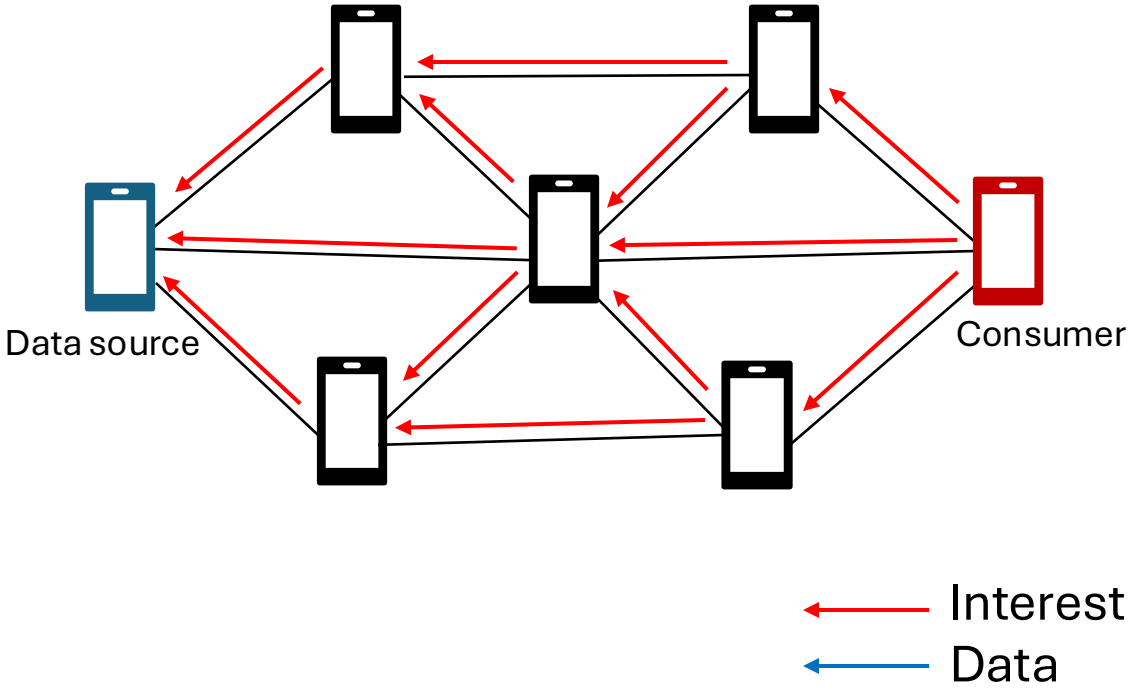
Introduced components:

- Content Manager
  - *Access and store content* in Repository as user request
  - *Create Interest* when the requested content is not available in Repository
  - *Push local directory information* to network
- D2D Communication Manager
  - Manage *D2D connections*
  - Manage *D2D Faces* and its *FIB records*
  - *Passing message* between NDN Forwarder and D2D connections
  - *Send pending Interest* to newly-discovered device

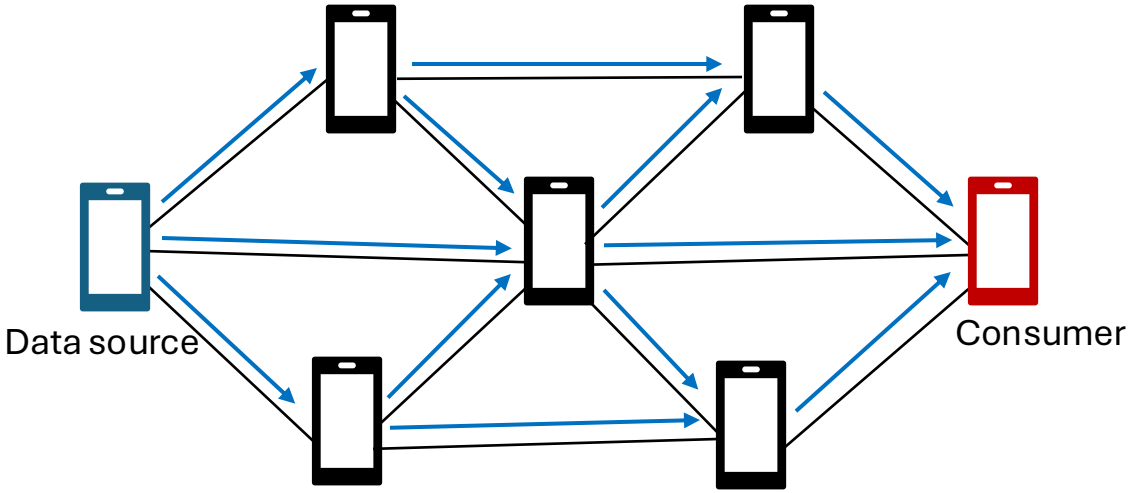
Content discovery and retrieval

- Content name : /D2D/lesson1/part1.mp4/(chunk no.)

1. Send Interest for the first chunk
   /D2D/lesson1/part1.mp4/1



2. The returning Data of the first chunk

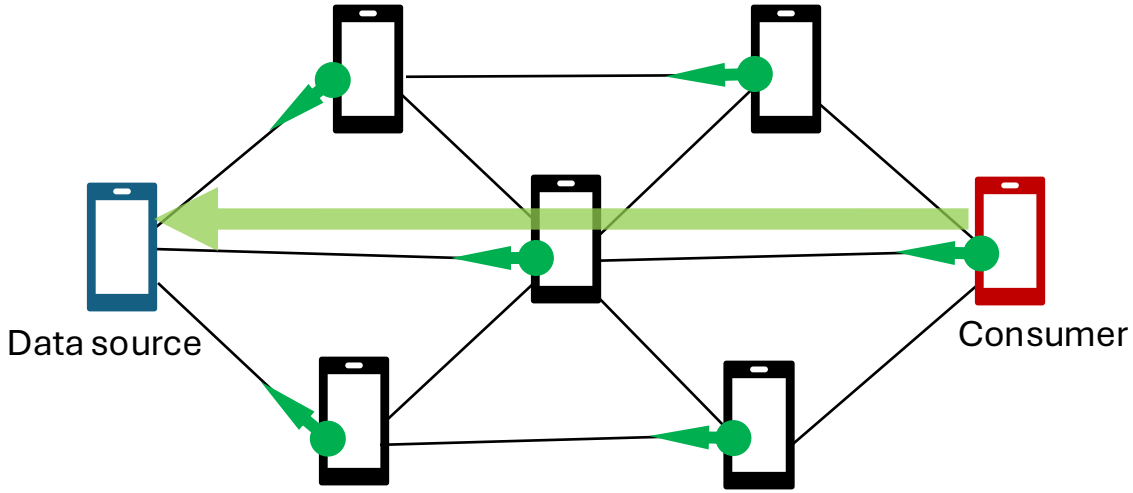


(E. Baccelli et.al., 2014)

Content discovery and retrieval

- Content name : /D2D/lesson1/part1.mp4/(chunk no.)

3. Building paths of prefix:
/D2D/lesson1/part1.mp4



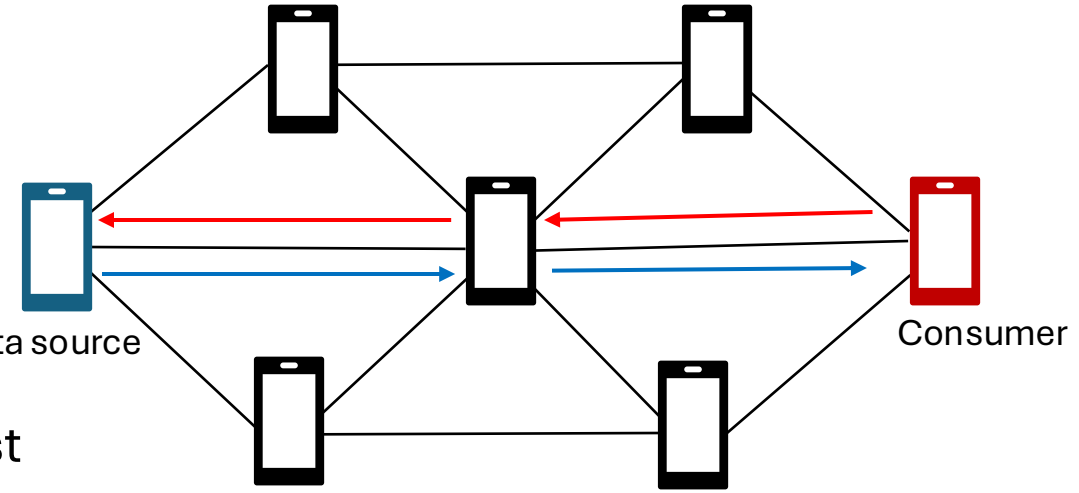
Next-hop face for the prefix

Path from consumer to data source

Interest

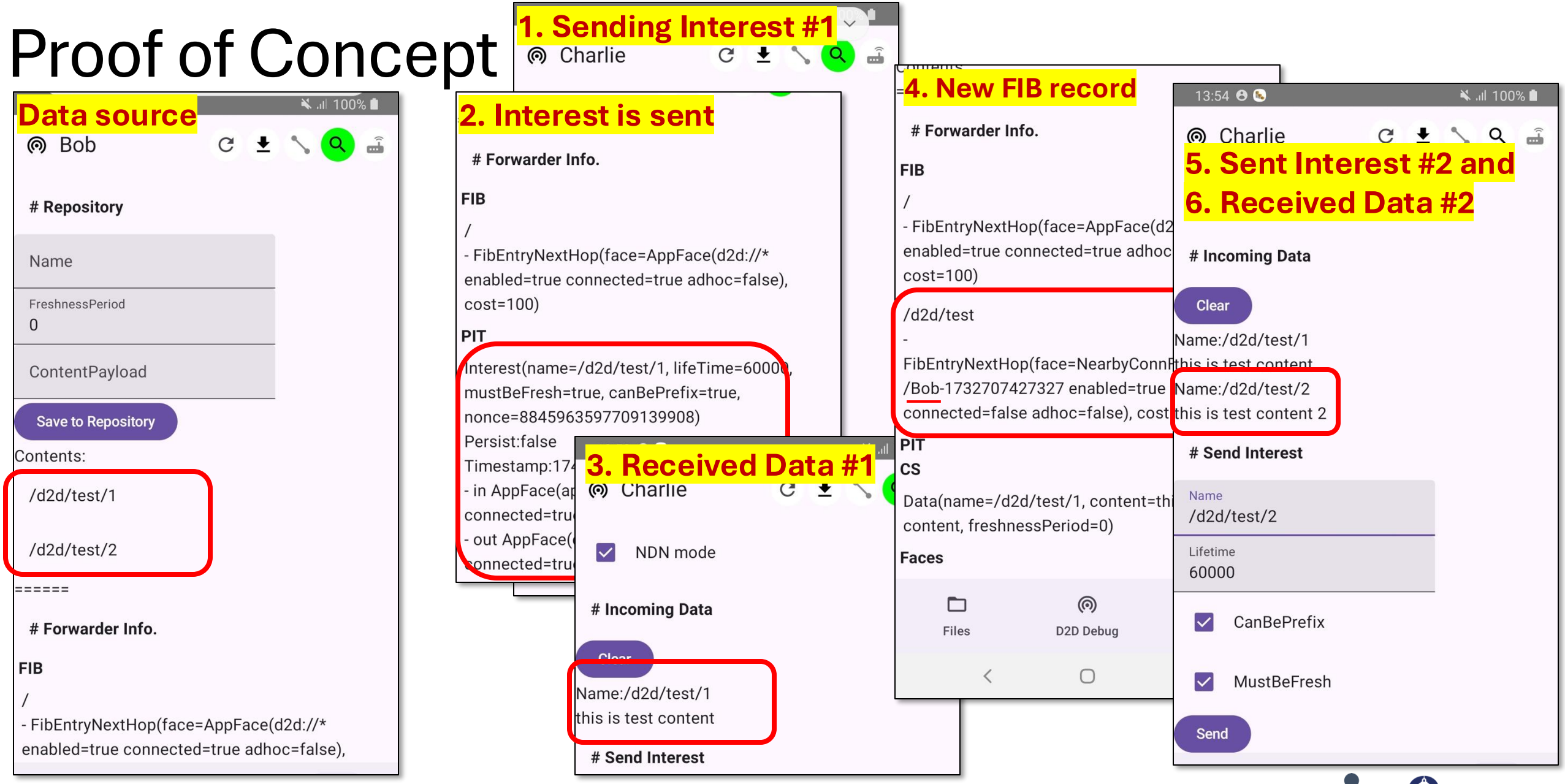
Data

4. Subsequence chunks are routed.
/D2D/lesson1/part1.mp4/2



(E. Baccelli et.al., 2014)

Proof of Concept



Key takeaways

- This research highlights that increased content access elevates the importance of ICN. When content is available within the network, ICN can deliver it, although delivery time depends on the network topology.
- Pre-downloading is becoming increasingly important as it reduces the dependency on network conditions.
- For successful delivery, D2D contact time is crucial. To ensure complete file transfer, large files should be divided into smaller chunks and reassembled at the requester node before viewing.
- Further studies are required for performance tuning aspects including caching, chunk sizes, and contact time.

Future plans

- Real-world experiments
  - At migrant worker's camp in Samut Sakhon, Thailand, around April-May 2025
- Performance tuning
- Interoperability with Internet connections, exchanging content with remote D2D networks and cloud servers.
- Expand application to Real-time video/audio streaming, chat messaging and virtual classroom

Thank you