On the Feasibility of a User-Operated Mobile Content Distribution Network

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Feasibility

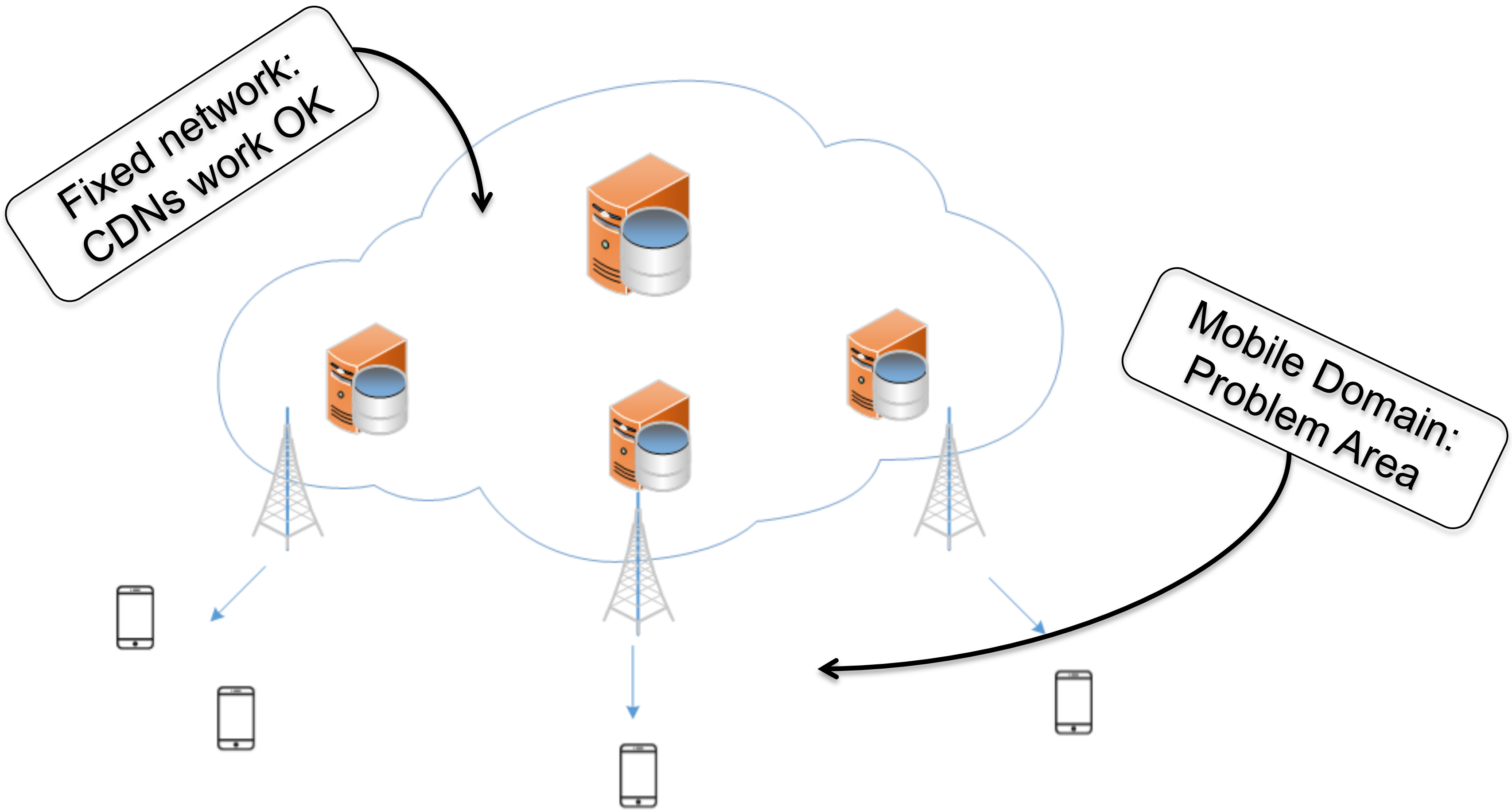
Mobile

User-Operated

Content Distribution Network (*aka* CDN)

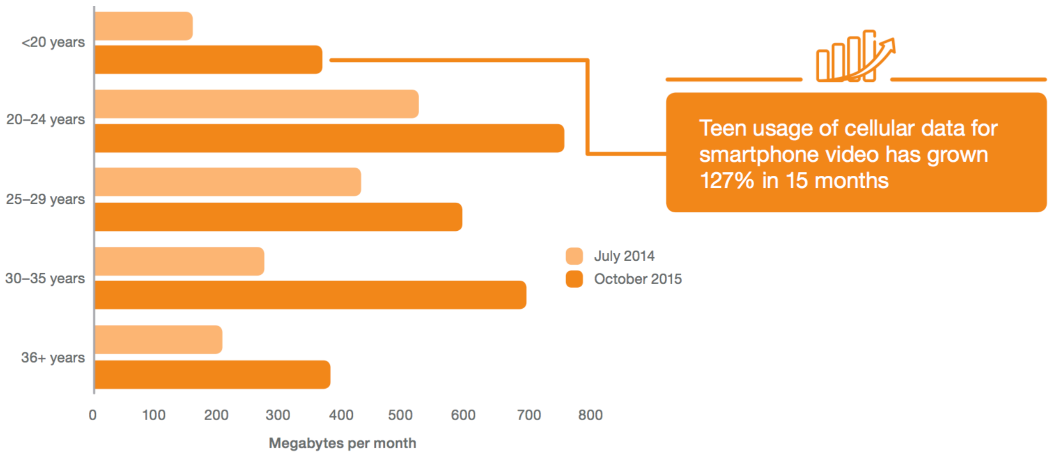
Data caps cannot keep up with demand for mobile video delivery

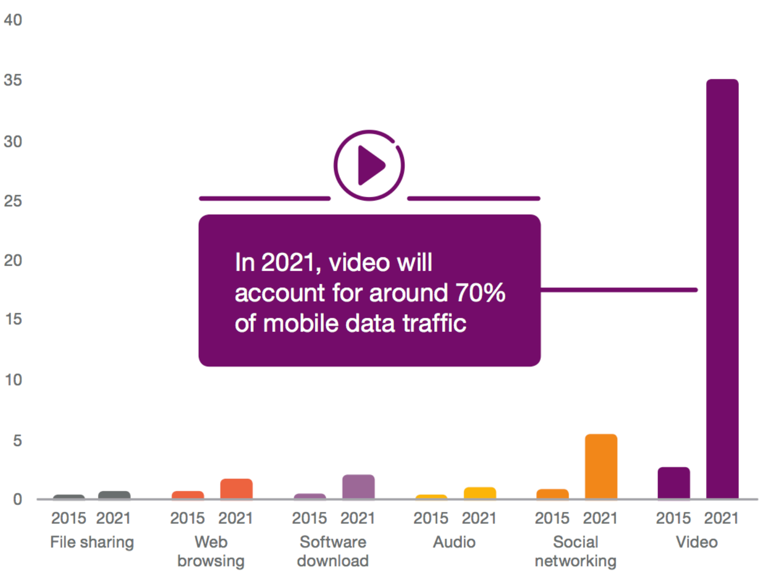
Facts I: CDNs focus on the fixed domain



Facts II: Mobile Video will Skyrocket

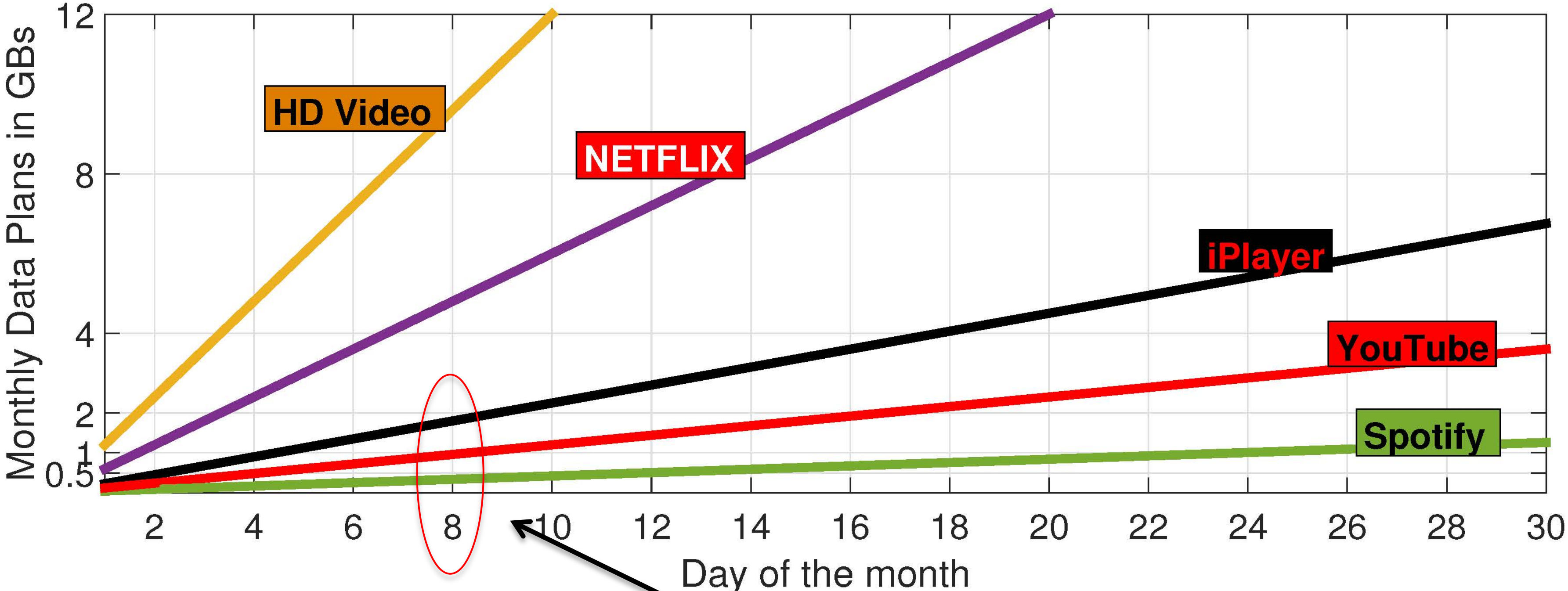
Given the massive explosion of video content available on the internet, there is a corresponding sharp increase in streamed video viewing, particularly among younger generations. Today's teens are streaming natives, as they have no experience of a world without online video streaming





*Ericsson Mobility Report, 2016

Mobile Data in terms of Video

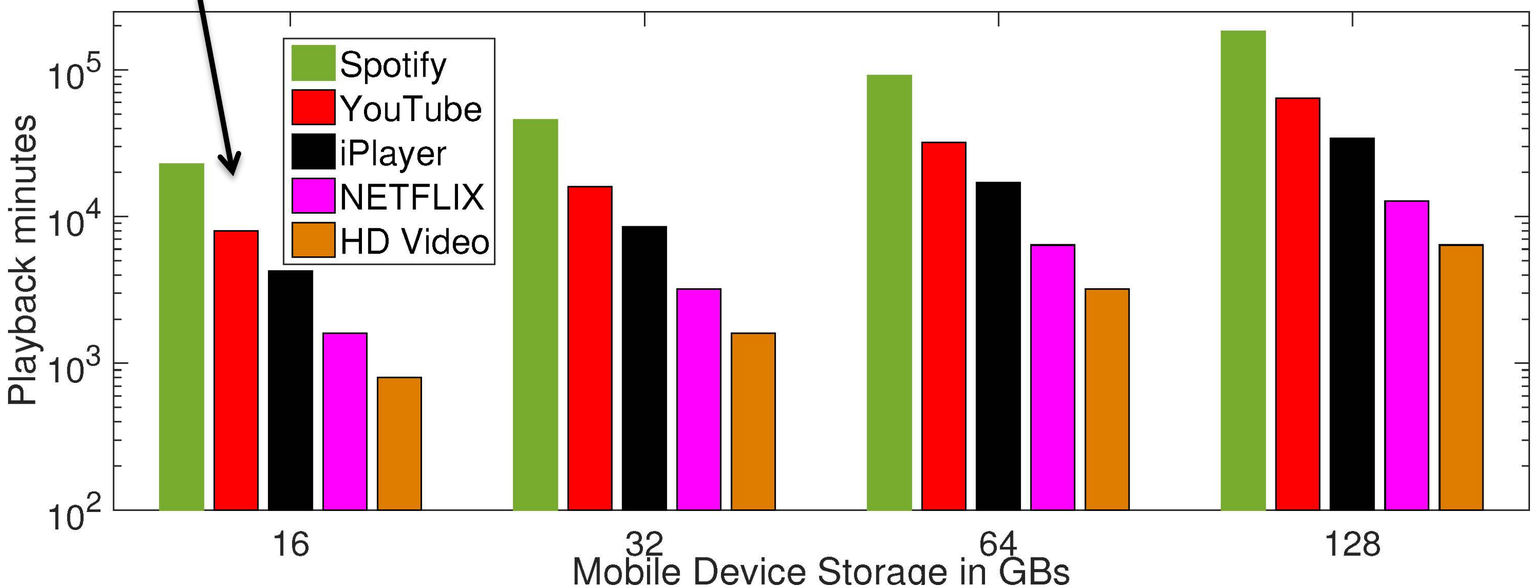


One hour of streaming per day (e.g., during commuting) consumes a 2GB data plan in less than 10 days!

Mobile micro-datacentres

All modern smartphones have at least 16GBs of memory

16 GBs of memory translates to nearly 1,000 minutes of YouTube or 100 10-min YouTube videos



Modern smartphone devices are ***always-on, always-connected, mobile data-centres*** for short audio/video-clips

Working Example

- Assume:
  - ✓ BBC application installed in 10M end-user devices – that's roughly 1 in 6 devices you see around (in the UK)
  - ✓ End users split in: *1) source, 2) destination, and 3) relay nodes*

Result: Huge amounts of content is proactively put in users' devices in an *application-centric manner*.

① Content Providers (CPs), say BBC, publish one new video-clip every 1 hour

② CPs push the video to a limited number of source nodes – source

Challenge: Can we have every video-clip *pre-loaded* to the users' devices before new content comes out (i.e., within 1h)?

④ Once updated, destination nodes can act as relay nodes for a limited amount of time.

ubiCDN
a distributed and ubiquitous content distribution network for data delivery at the mobile domain.

ubiCDN exploits user mobility in urban environments to proactively distribute non-real time content

Content spreads through smart, **Information-Centric Connectivity**

ubiCDN Components

- **Node Groups**
  - *Source nodes:* get new content pushed to their devices
  - *Destination nodes:* passively wait to receive updates
  - *Relay nodes:* act as source nodes for limited time
- **D2D Information-Aware and Application-Centric Connectivity**
  - WiFi Direct Generic Advertisement Service (GAS) protocol
  - Devices advertise services/applications, e.g., `BBC-Sports-11am`
- **Incentives**
  - Source and Relay nodes are compensated
  - Compensation proportional to content distributed
- **Data Integrity/Content authentication**
  - Digital certificates from CPs
  - Digital Signatures based on Public Key Infrastructure (PKI)
  - Source and Relay nodes: Storage Delegates

*K.V. Katsaros et. al. "Information-Centric Connectivity", IEEE Communications Magazine, August 2016.

Opportunistic Content Distribution in an Urban Setting

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#University of Cambridge

ABSTRACT

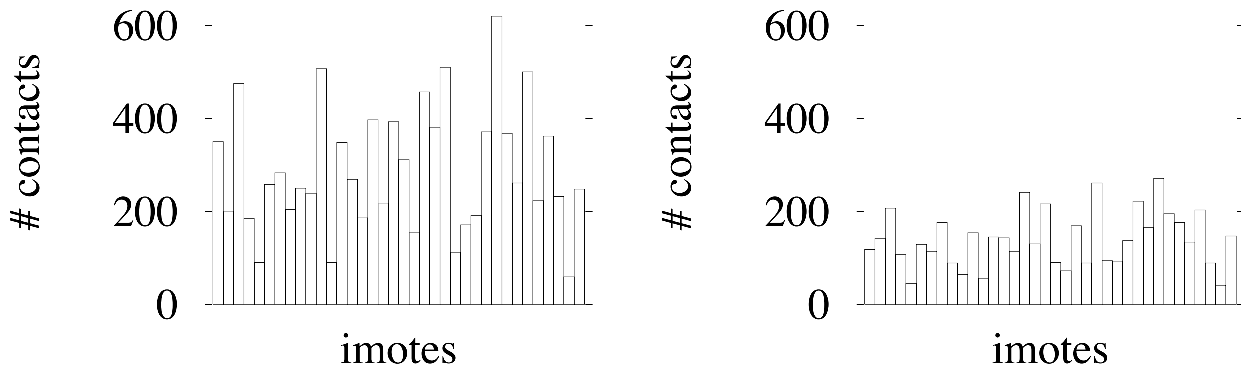
This paper investigates the feasibility of a city-wide content distribution architecture composed of short range wireless access points. We look at how a target group of intermittently and partially connected mobile nodes can improve the diffusion of information within the group by leveraging fixed and mobile nodes that are exterior to the group. The fixed nodes are data sources, and the external mobile nodes are data relays, and we examine the trade off between the use of each in order to obtain high satisfaction within the target group, which consists of data sinks. We conducted an experiment in Cambridge, UK, to gather mobility traces that we used for the study of this content distribution architecture. In this scenario, the simple fact that members of the target group collaborate leads to a delivery ratio of 90%. In addition, the use of external mobile nodes to relay the information slightly increases the delivery ratio while significantly decreasing the delay.

to create communication possibilities with users and devices in other places, even when if there never exists a fully connected path between the two end-points. These networks are a type of delay tolerant network (DTN) [4] and fall also under the Pocket Switched Networking (PSN) paradigm [2]. In this context, this paper investigates the feasibility of a city-wide content distribution architecture for electronic newspapers or local information. We look at how a target group of intermittently and partially connected mobile nodes can improve the diffusion of information within the group by leveraging various mixtures of fixed and mobile nodes that are exterior to the group. The fixed nodes are data sources, and the external mobile nodes are data relays, and we examine the trade off between the use of each in order to obtain high satisfaction within the target group, which consists of data sinks.

To evaluate the different content distribution schemes we propose, we conducted an experiment in the city of Cambridge, UK, in which 20 stationary devices equipped with a

SIGCOMM'06 Workshops September 11-15, 2006, Pisa, Italy.

Figure 1: Locations of fixed iMotes.



(a) Total (b) Unique

Figure 7: Contacts between external devices and mobile iMotes.

Target of this study

Feasibility of a user-operated CDN

- define *"Feasibility"*

What percentage of population is updated within *reasonable time-frames**?

F1: How many source nodes are needed?

F2: What's the impact of relaying?

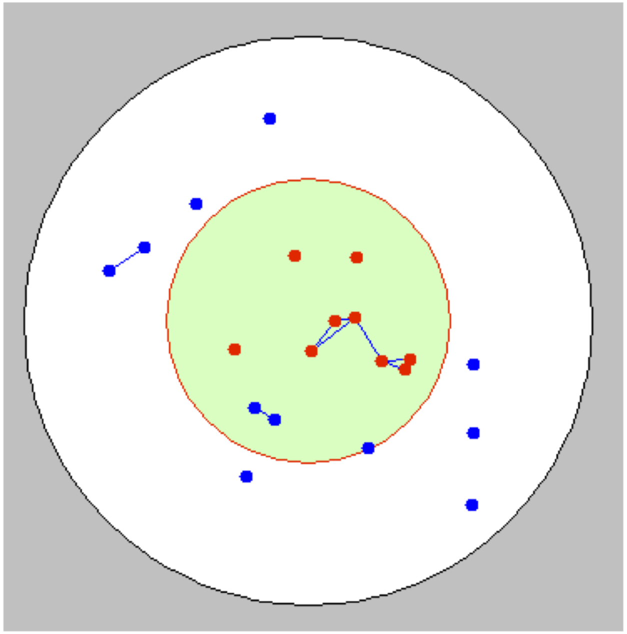
F3: What's the impact on battery?

- Metrics:
  - **Satisfaction rate:** percentage of nodes updated within update interval
  - **Overhead:** duplicates, messages of no interest or incomplete transfers
  - **Relayed content:** percentage of messages delivered by relay nodes
  - **Energy consumption:** what percentage of battery is consumed for ubiCDN

* We define this as "update interval" and set it to 1 hour.

Evaluation: Setup and Assumptions

- ubiCDN implemented on the *ONE* simulator.
- Set of 10 applications, Pareto-distributed by popularity and randomly distributed among users (at least one application per user).
- We compare it with Floating Content.

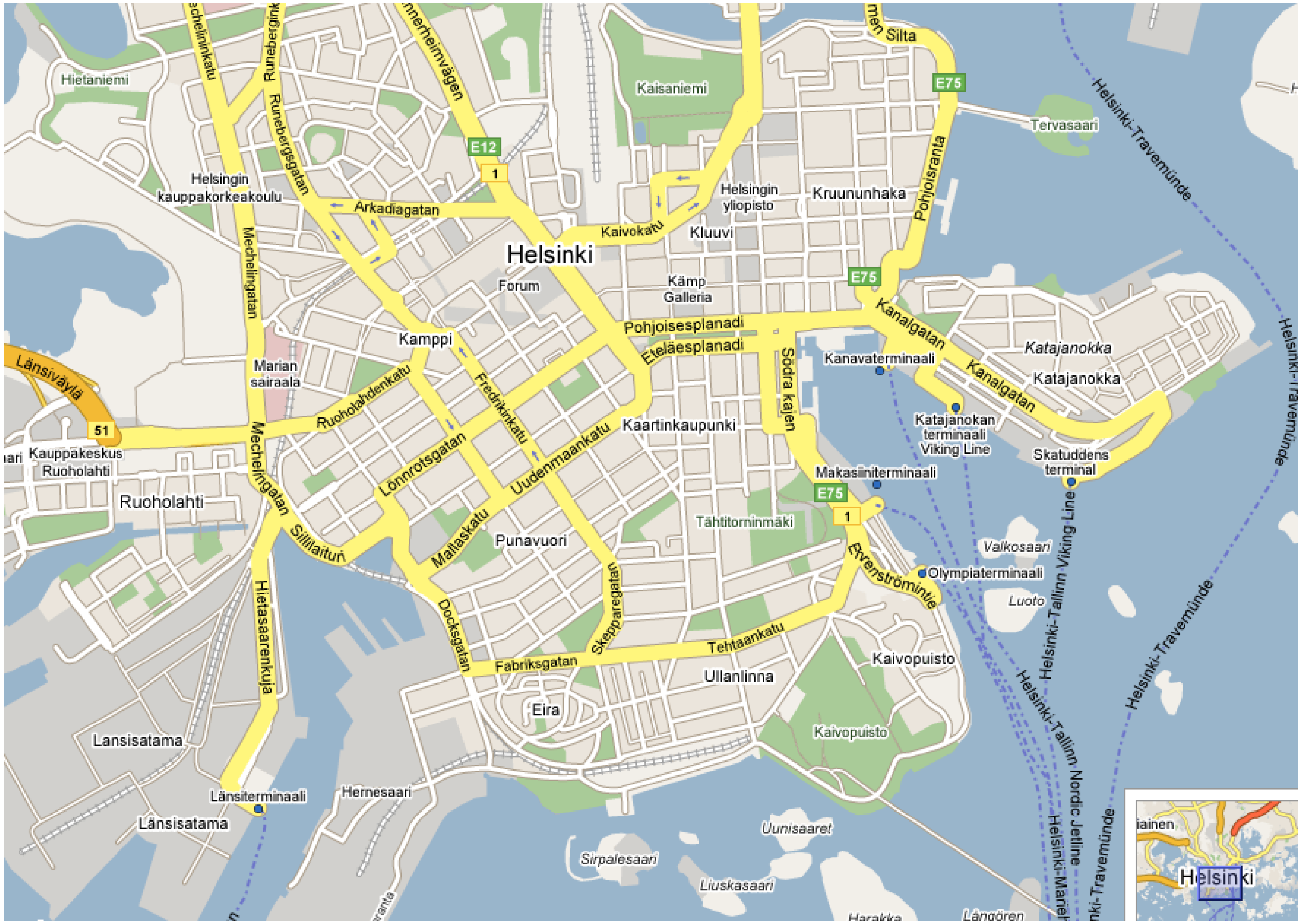


Floating Content

- Messages stay within some area
- Messages live for some specific amount of time

*Joerg Ott *et al.* www.floating-content.net

Evaluation: Setup and Assumptions



Helsinki simulation area

Evaluation: Setup and Assumptions

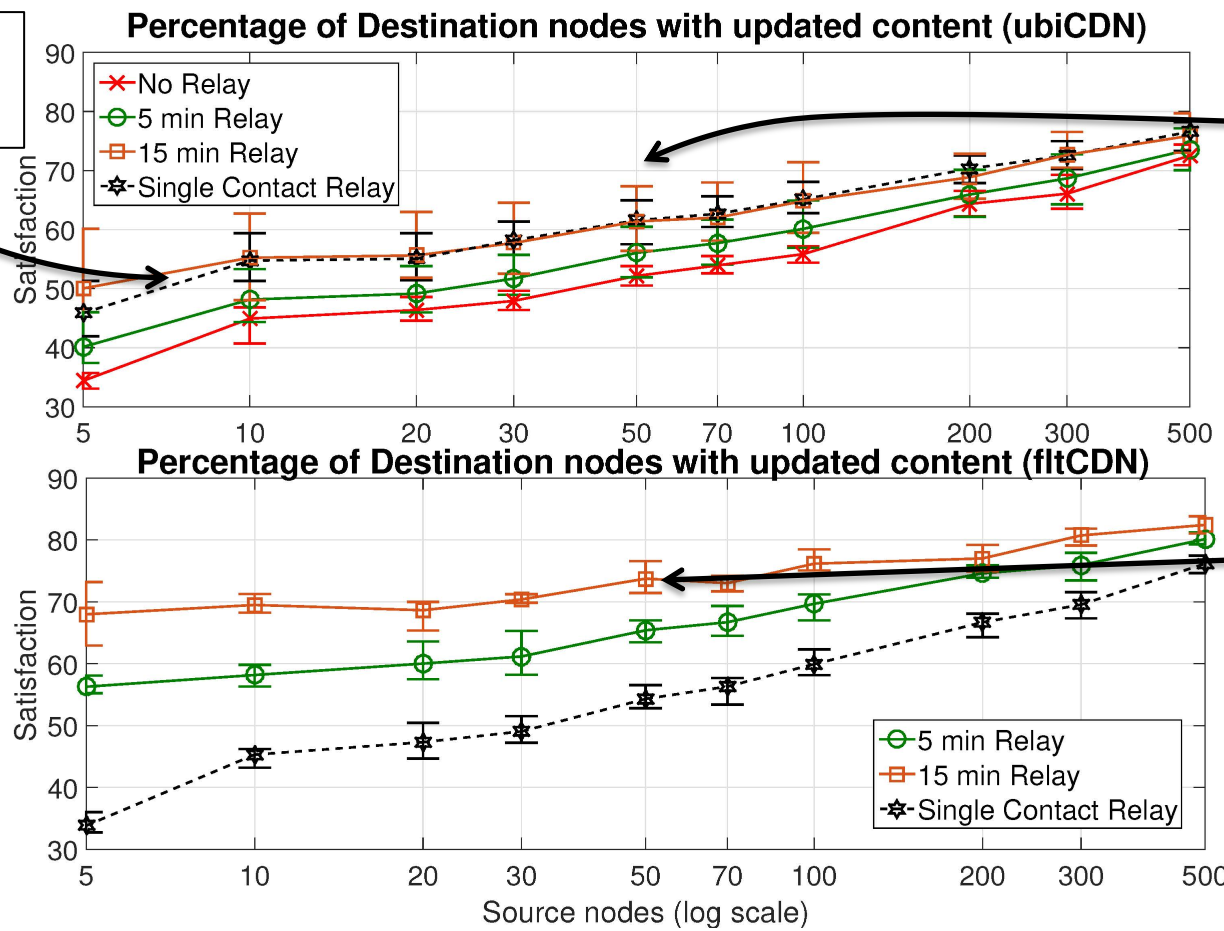
- Urban movement: 8.3km x 7.3km area
- Multiple movement patterns map-based defined:
  - **Source Nodes (50):**
    - 18 Buses on predefined routes.
    - 32 working day movement model with 50% evening activity
  - **Destination Nodes (1000):**
    - *Tourists (20% of destination nodes):* Random travel destinations including “points of interest” to which they travel following the shortest path, wait randomly between 2-15 minutes and then move again.
    - *Workers (80% of destination nodes):* Working day movement model: Home to work (for 7 hours) + 50% probability of evening activity, before travelling back home

Evaluation: Setup and Assumptions

Parameter	Value
Number of Applications	10
Number of Source Nodes	50
Number of Destination Nodes	1000
Size of each message	5 MBs
App. update period	1 hour
D2D Link Capacity	31.25Mbps
Radio Range	60 m

Feasibility 1: Number of source nodes

Exponential increase

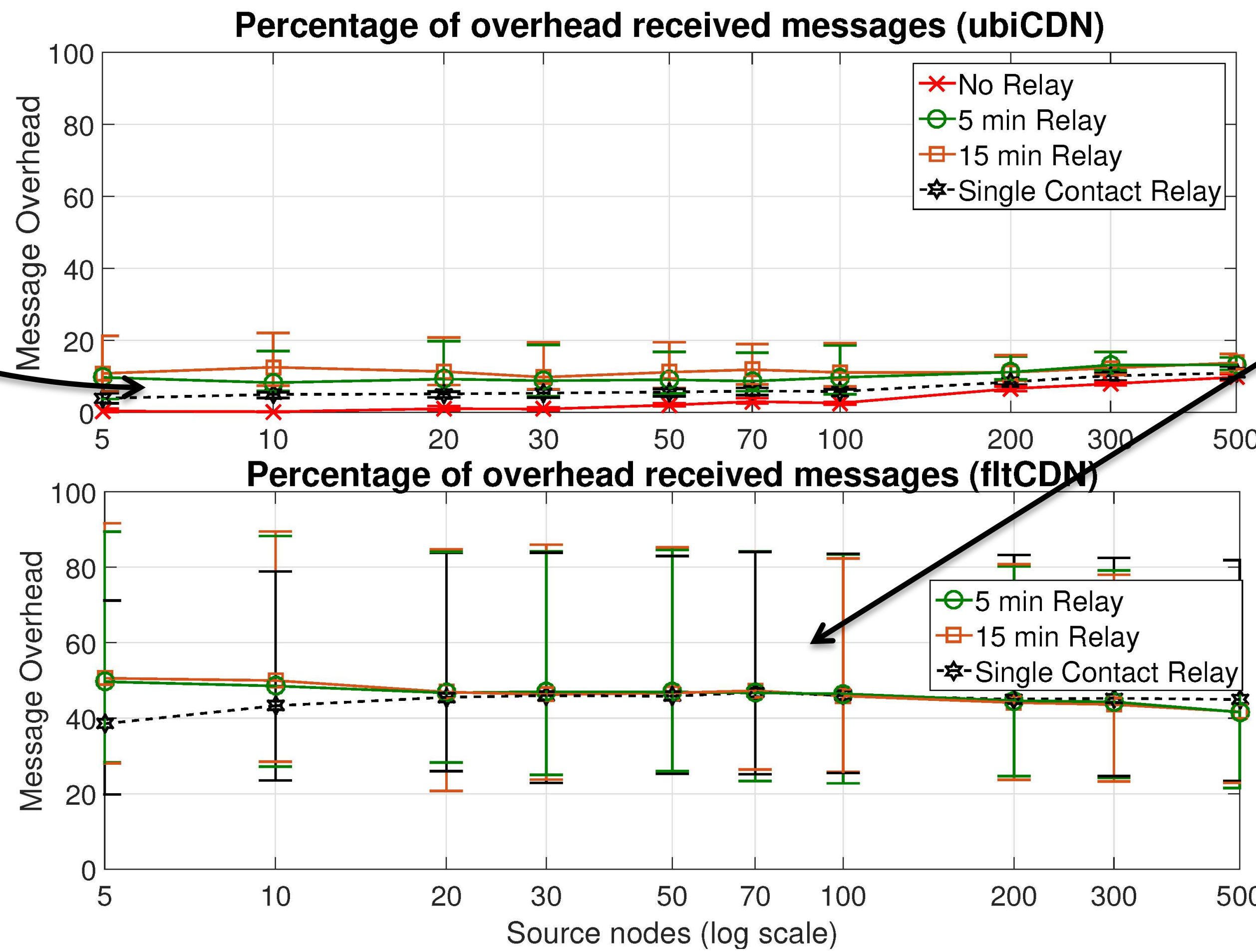


5% of nodes reach out to 60% of population

Flooding is more efficient, but…

Feasibility 1: Number of source nodes

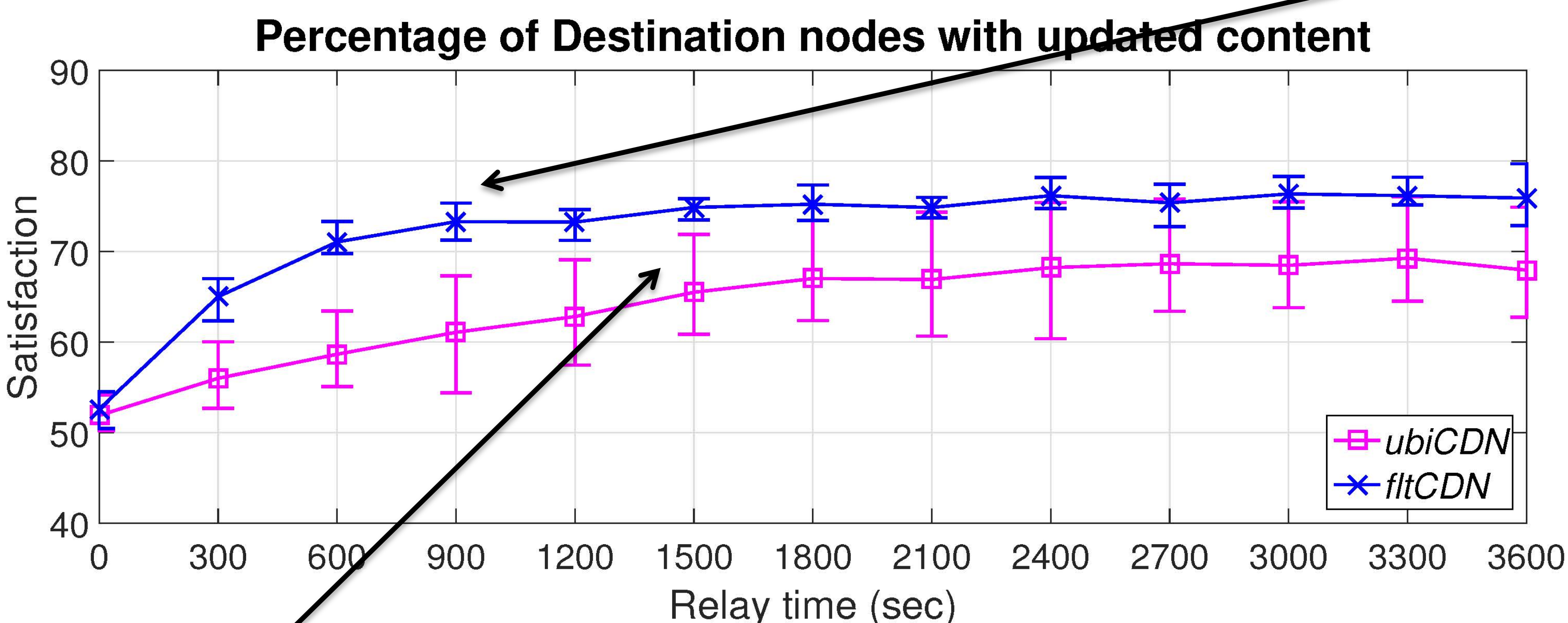
Less than 10% overhead – mainly due to mobility



Significant overhead – up to 50%

Feasibility 2: Impact of Relaying

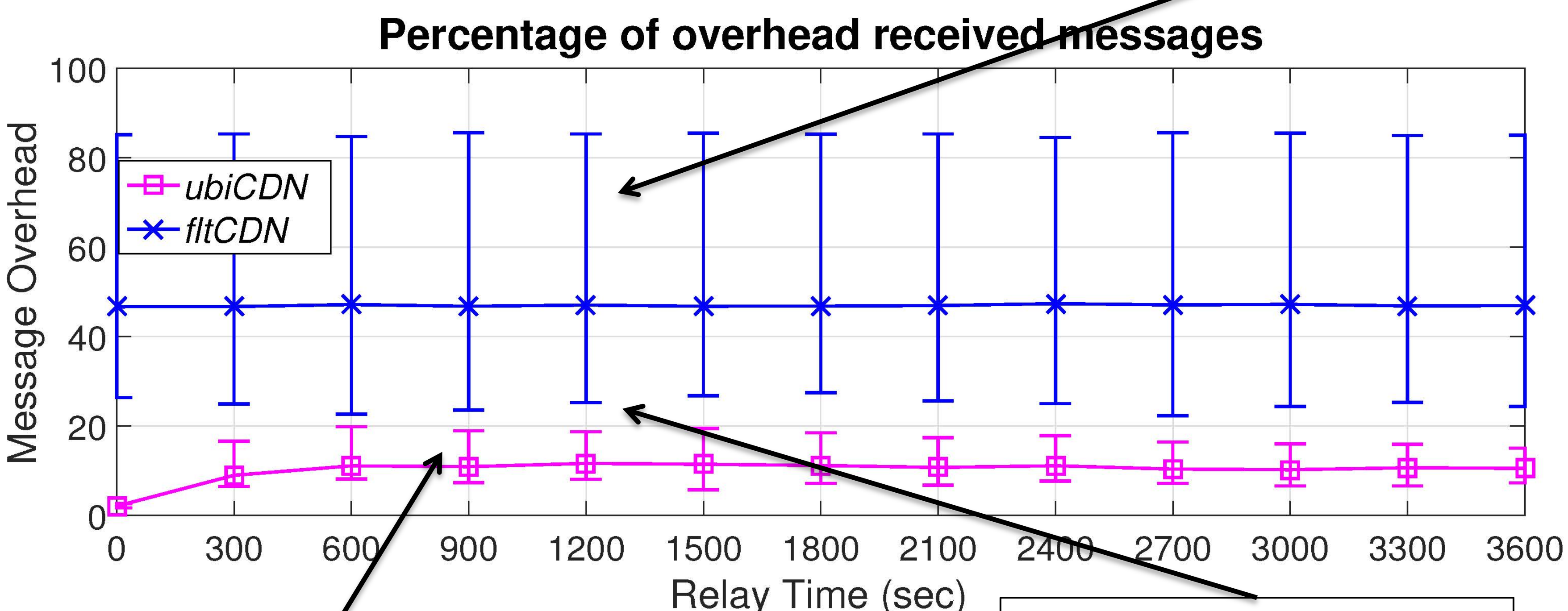
Substantial gain (up to 40%) after 5-15*mins*



ubiCDN gains from up to 30*mins* of relaying

Feasibility 2: Impact of Relaying

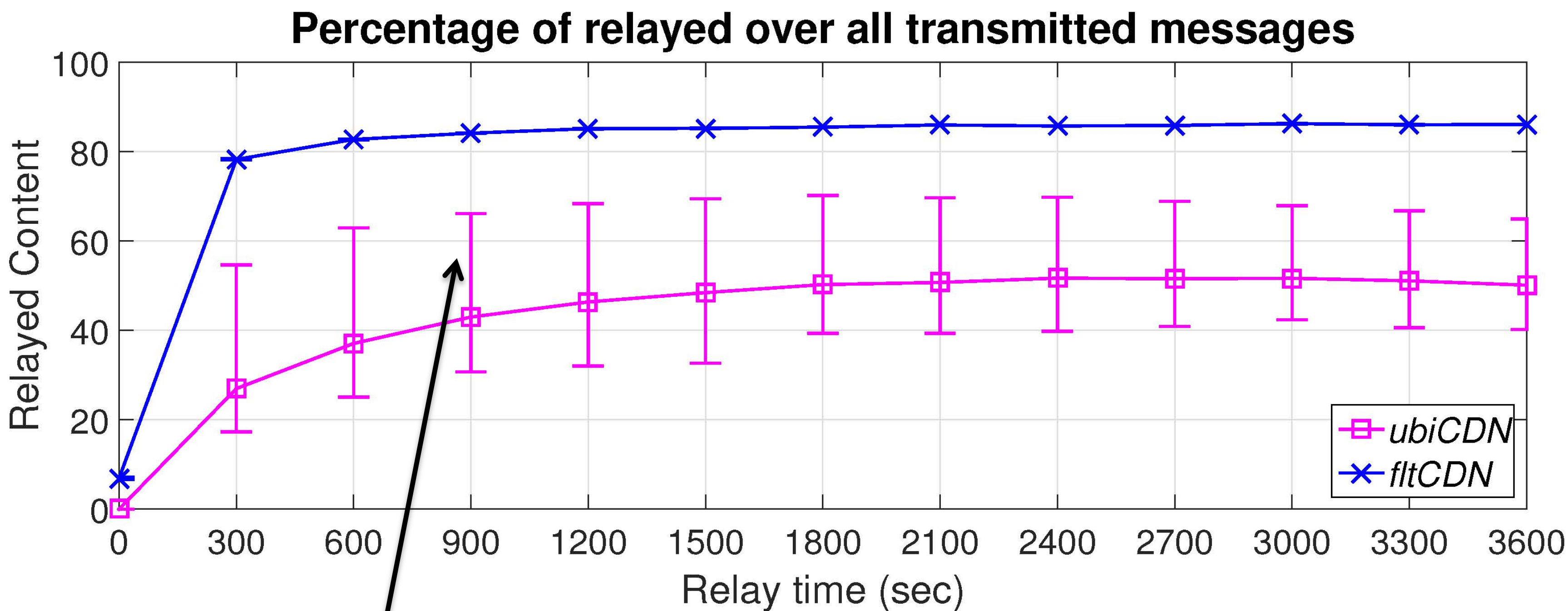
Up to 90% overhead using fltCDN



Bounded to 20% for ubiCDN

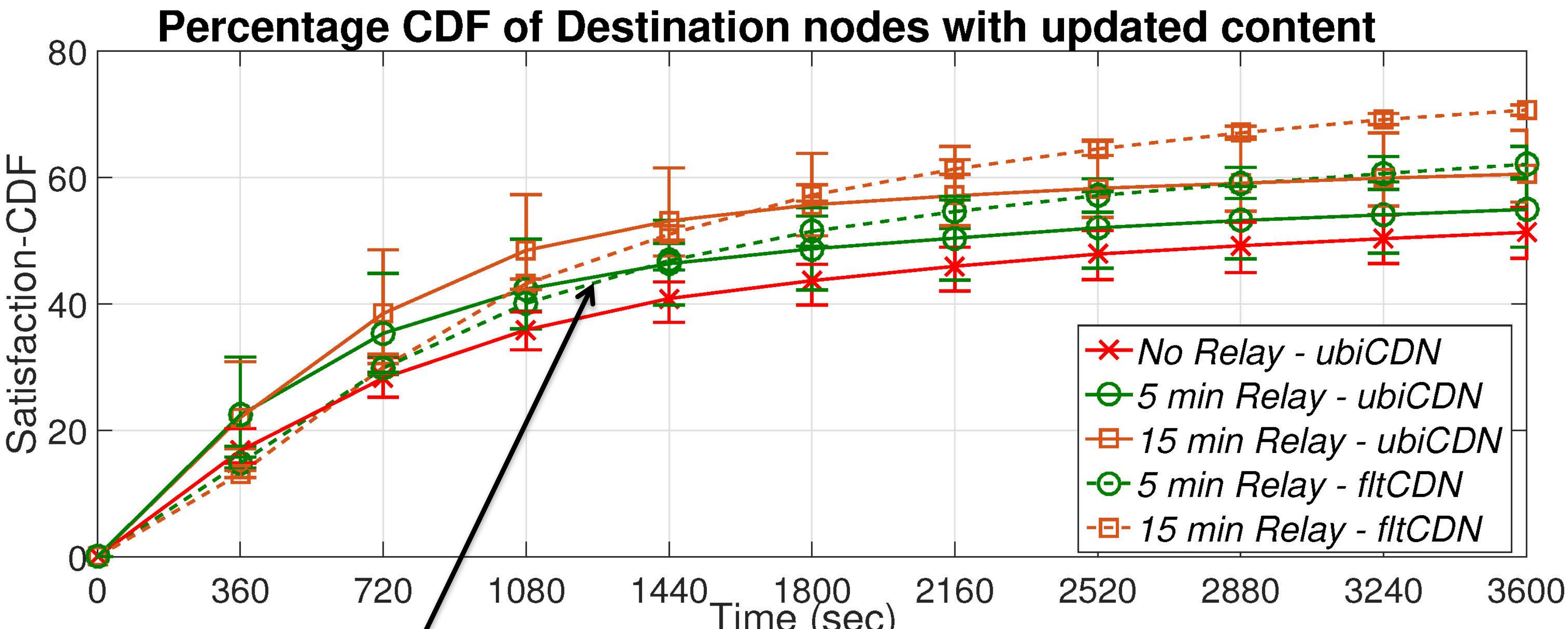
Space for Optimisation: Least popular applications cause little overhead

Feasibility 2: Impact of Relaying



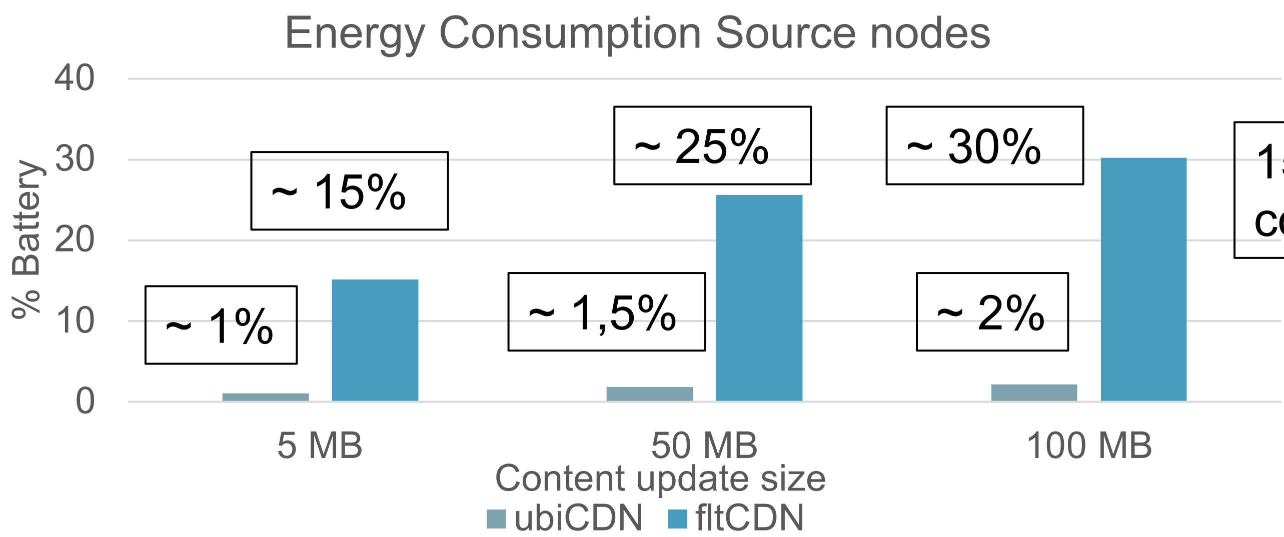
More than 40% (ubiCDN) / 80% (fltCDN) of distribution comes from relaying

Feasibility 2: Impact of Relaying

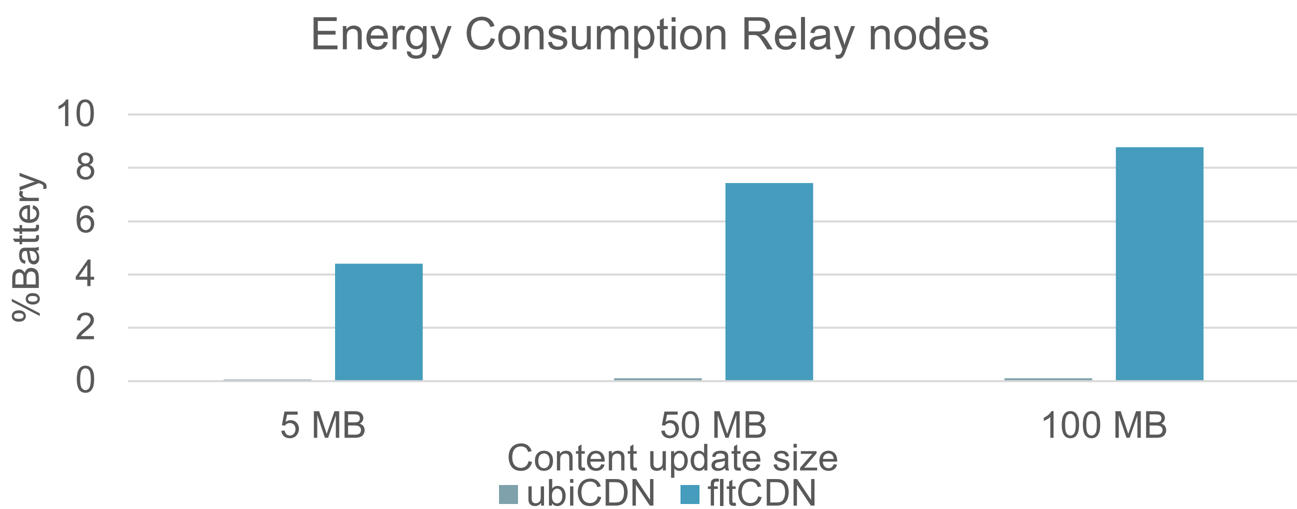


Most nodes get updated within the first 20-25 *mins*

Feasibility 3: Energy – the price to pay



15x less consumption



Conclusions

Data Caps cannot follow demand for mobile vide
- Expected to be about 8GBs in 2020

CDNs cannot reach the mobile domain
- Can't put a server after the BS

Pressing need for a solution to distribute heavy content in the mobile domain.

User devices as micro-data centres: **Opportunity not to be missed**

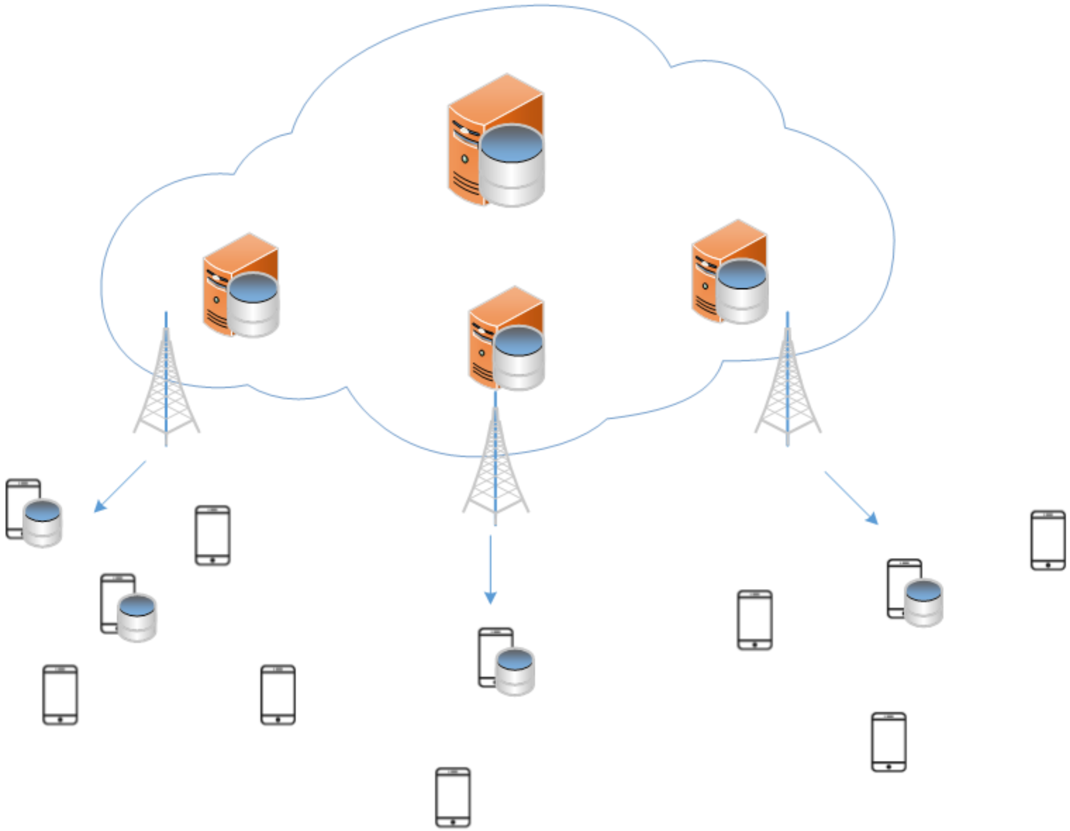
At least 50% of users updated within 30mins

Energy consumption is as low as 1% of battery capacity per hour.

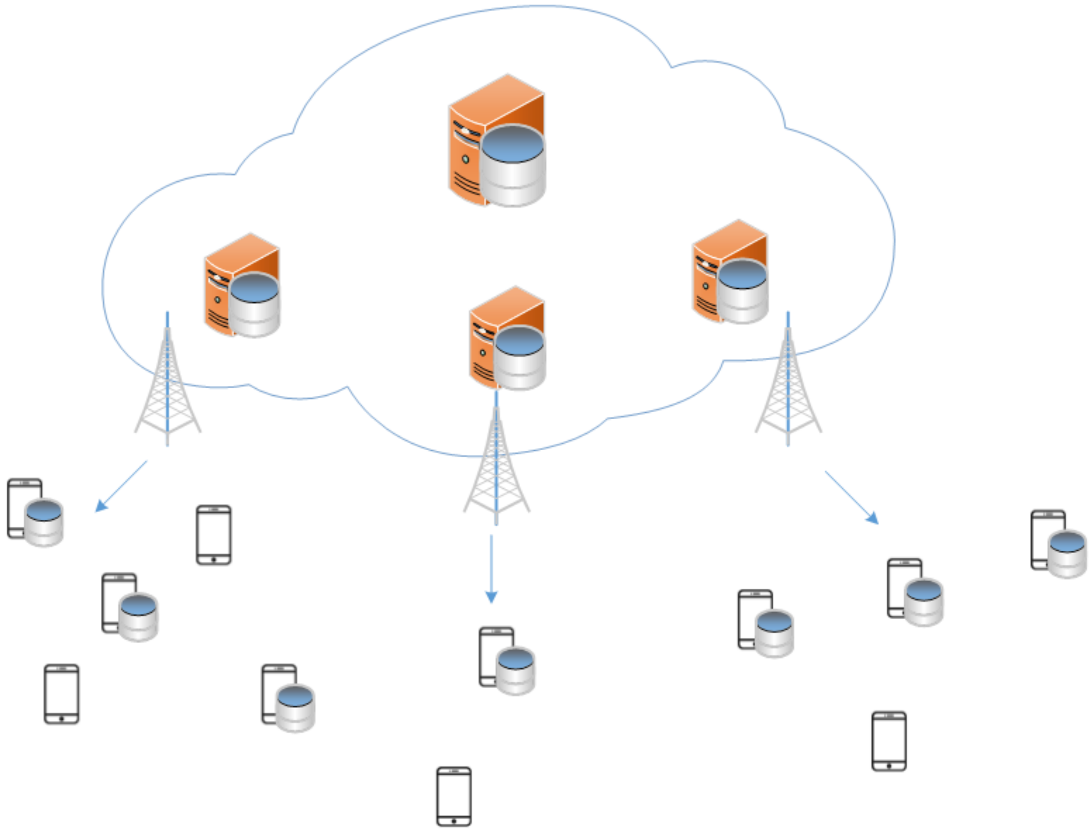
Information-Centric Connectivity is necessary in this case

BACKUP SLIDES

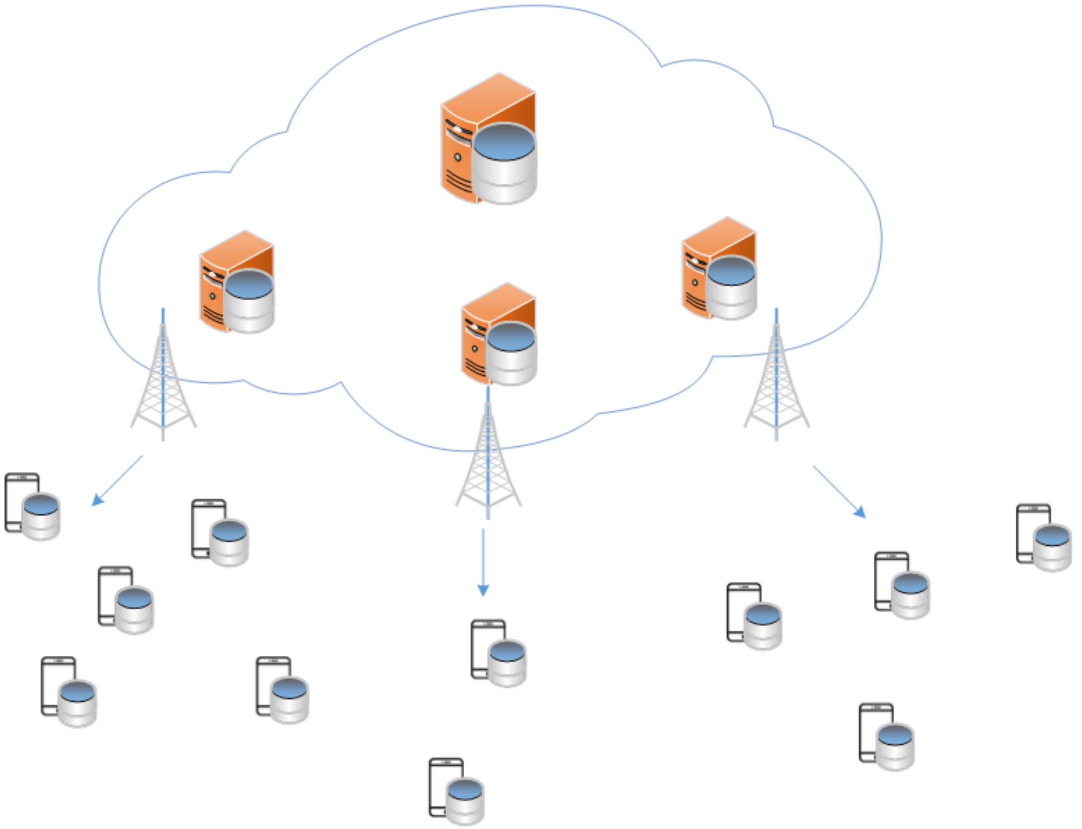
ubiCDN



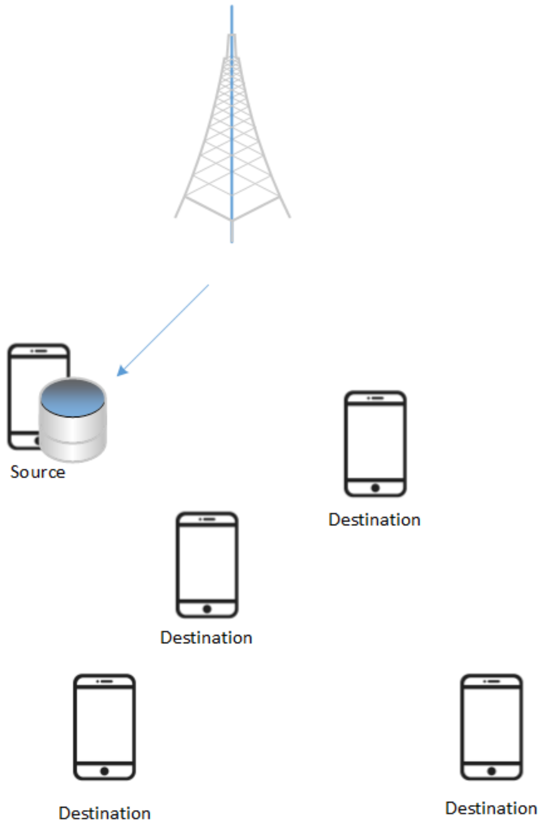
ubiCDN



ubiCDN



ubiCDN


Source
Destination
Destination
Destination
Destination

Information-Aware and Application-Centric Connectivity

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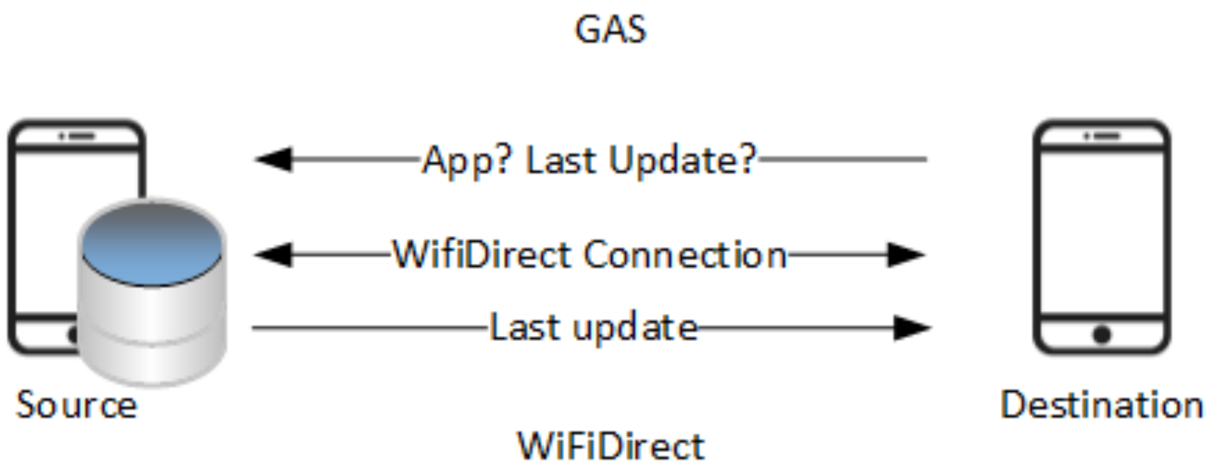
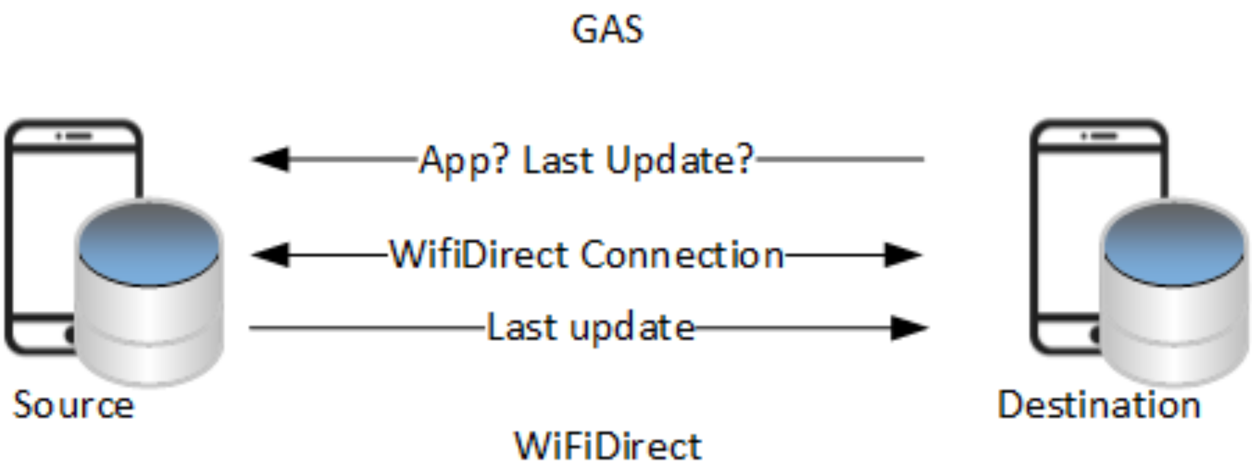


Information-Aware and Application-Centric Connectivity



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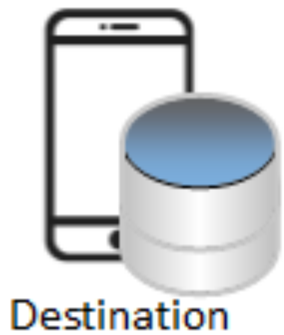

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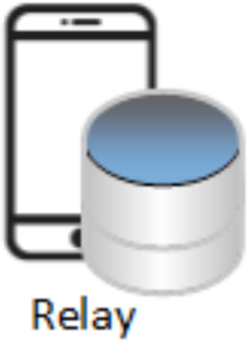

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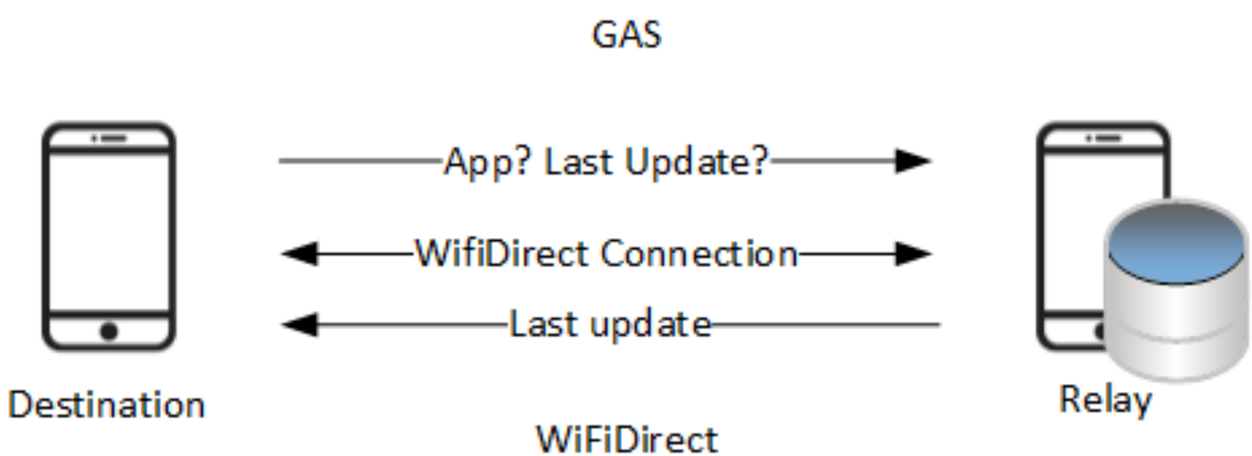

Information-Aware and Application-Centric Connectivity