Keyword-Based Mobile Application Sharing through Information-Centric Connectivity

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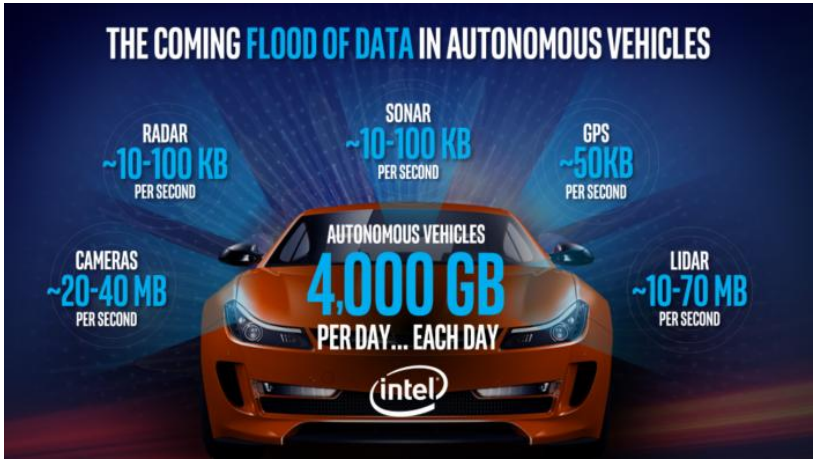
The Cloud is not enough



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- Always trying to reach the cloud does not work
  - E.g. trains, airplances, crowded areas
- 5G needs to integrate some edge-computing functionality
- The cloud is neither the only nor the best way
- There are enormous amounts of computation and storage available around us
  - 5G has to exploit the computation, storage and software resources of edge devices (smartphones, tablets, Raspberry PIs, WiFi APs)
- Connecting randomly to the nearest device does not work
  - **Information-Centric Connectivity** becomes necessity when we need to specify to which of the 100s of smartphone devices to connect to.
  - This need does not exist when we always connect to the main cell tower

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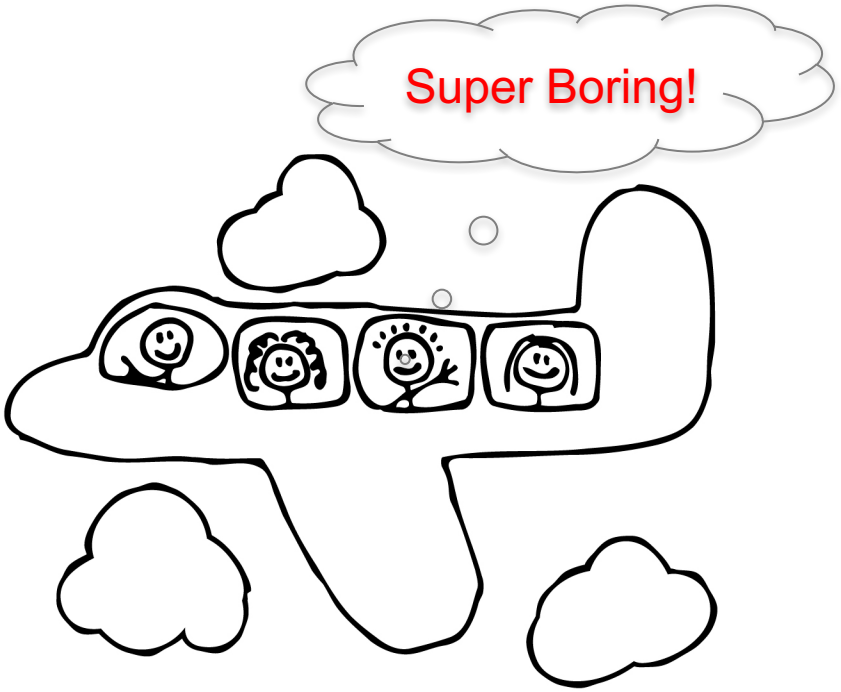
What is KEBAPP – Contribution

An *application sharing and information-processing* framework for smartphone apps

Route Finder App

Game or Video-Streaming Server



What applications does KEBAPP deal with – Design Space

- By and large, smartphone apps target:
  - **Static content**, *e.g.,* news updates
  - **Personalised content**, *e.g.,* Facebook/Twitter updates
  - **Processed information**, *e.g.,* route finder, gaming
    - *Keep demand for local services, locally!*

We envision a pool of *application resources* to provide D2D access to *processed and non-personalised information*

Where/When do we need KEBAPP (Target environments)

- Overcrowded areas
  - Airports, festivals, stadiums, IETF :)
- Fragmented networks
  - Natural disasters (floods, earthquakes)
- Not (or poorly) connected environments
  - Airplanes, trains, ferries, developing regions

In most of those cases, Internet connectivity is not even necessary!

How does KEBAPP work?

Applications act both as clients and as servers

Three Main Components

1) Application-centric naming

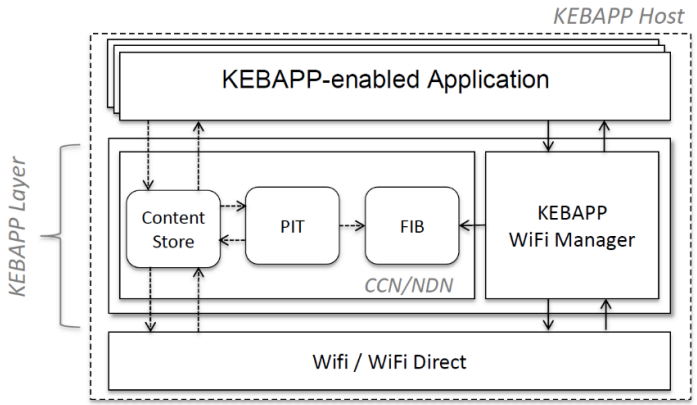
- Applications share common name-spaces and support the use of keywords

2) Application-centric connectivity

- Applications manage connectivity by defining and/or joining WiFi broadcast domains

3) Information-centric forwarding

- Extending Named Data Networking primitives



Content Store

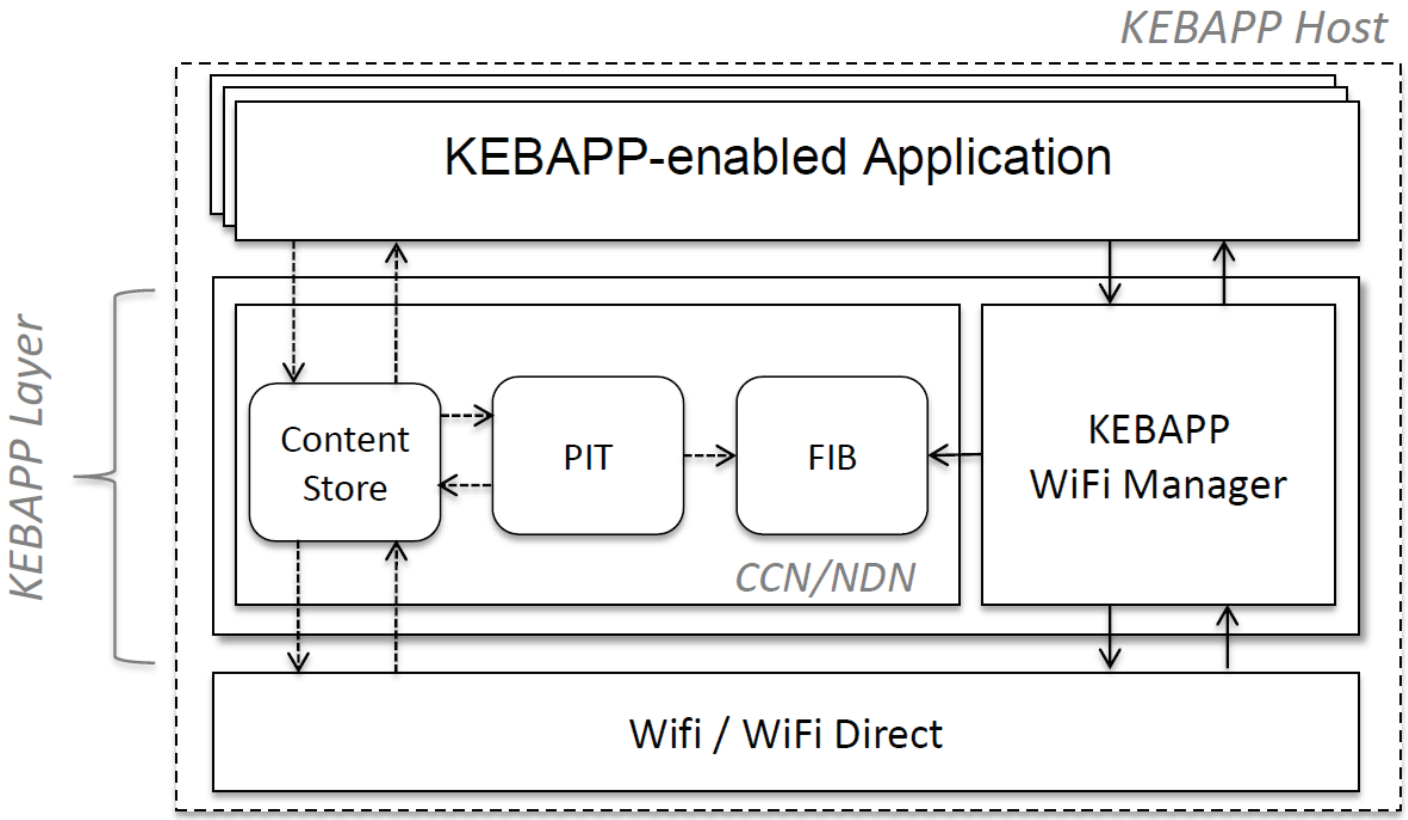
Data Chunck	Name
2a3b69e43f9bd48937	/d/e/f#t3#t4

PIT

In	Name	Out
Internal face #1	/a/b/c#t1#t2	BSSID1
BSSID2	/d/e/f#t3#t4	Internal face #2

FIB

Prefix	BSSID	Face
/a/b/c#t1#t2	BSSID1	Internal face #1
/d/e/f#t3#t4	BSSID2	Internal face #2



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FIB

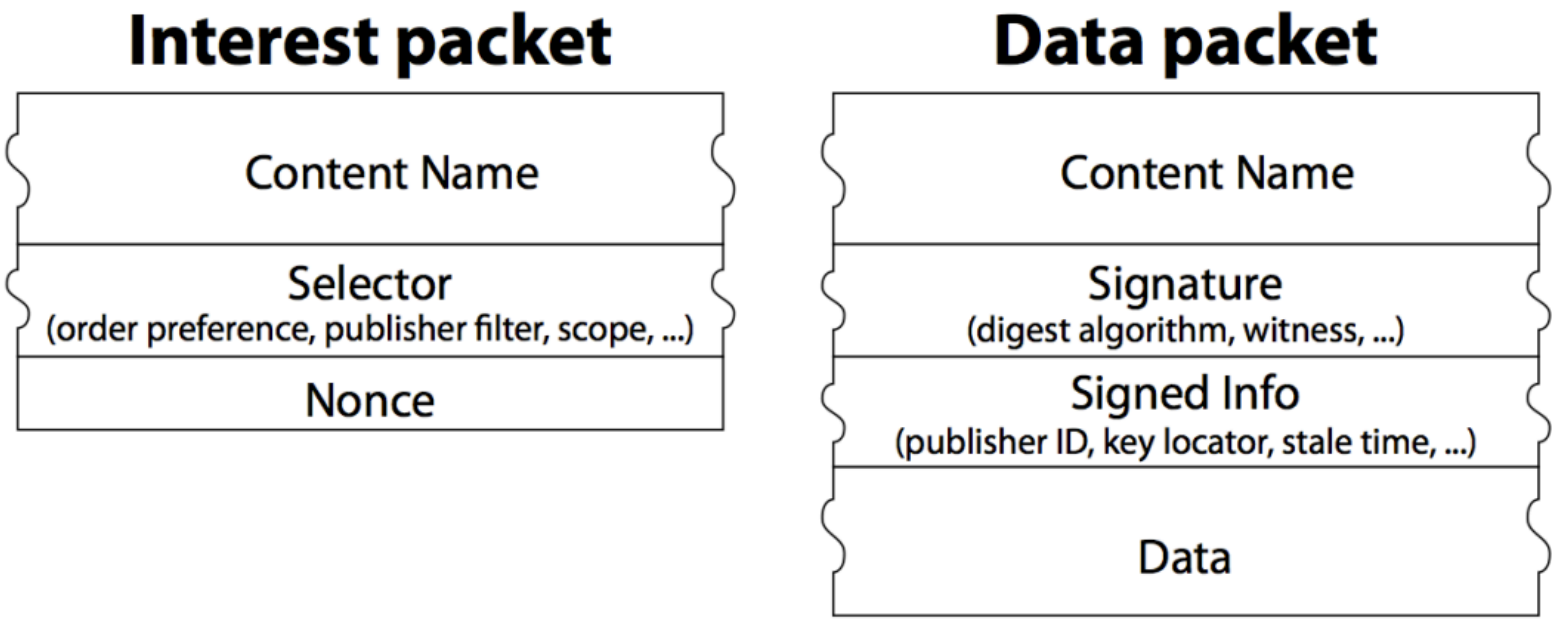
Prefix	BSSID	Face
/a/b/c	BSSID1	Internal face #1
/d/e/f	BSSID2	Internal face #2

Named Data Networking

Interest and Data Packets

Interest packet
Name
Nonce
Optional selectors

Data packet
Name
Content
Signature



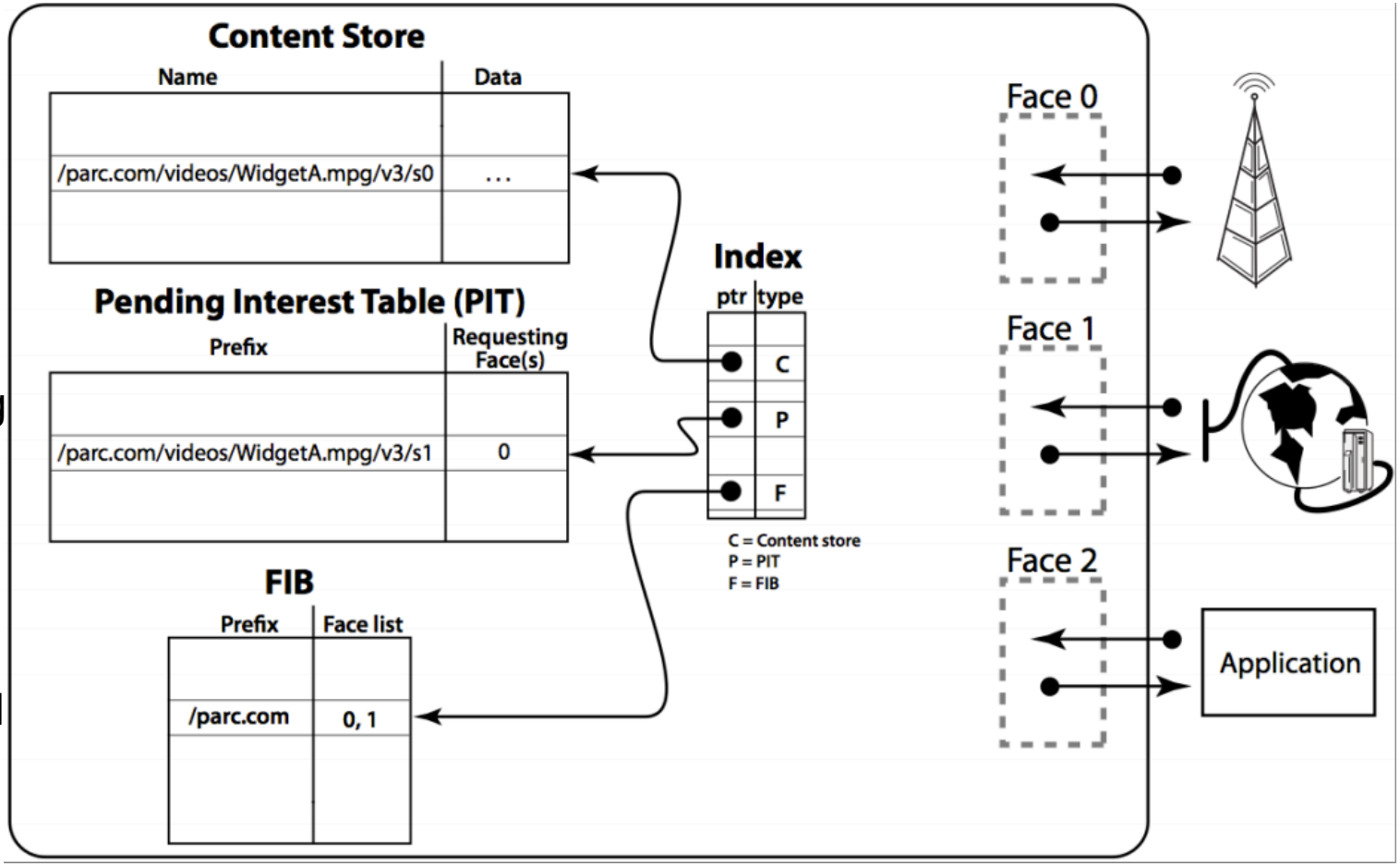
Names are defined by applications: /net/ucl/www/ipsaras/index.html

NDN Node Architecture
Three Tables

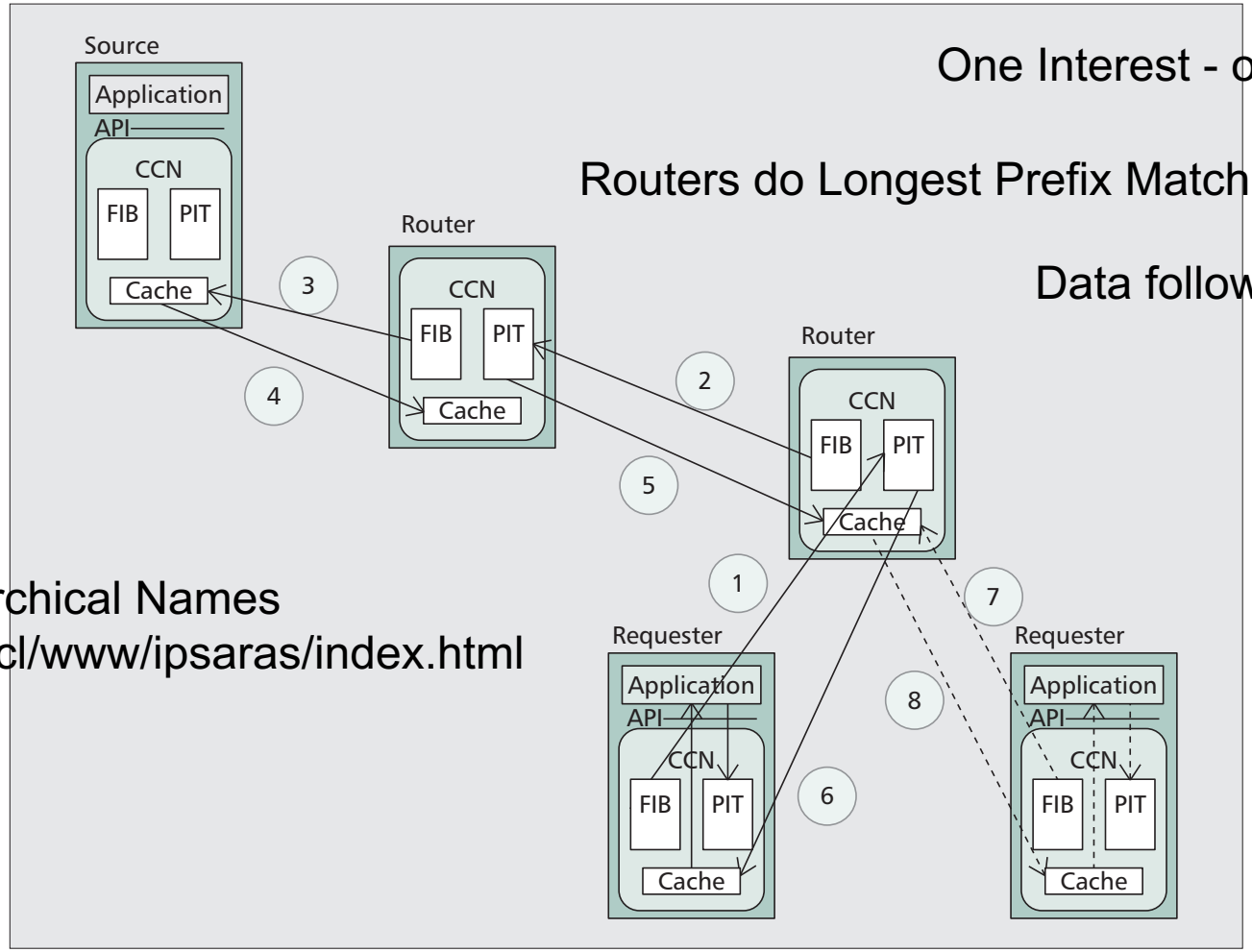
Cache Memory

List of outstanding Interests in terms of interfases

Table of outbound interfaces for Interests



NDN/CCN



One Interest - one Data packet

Routers do Longest Prefix Matching on Interests

Data follows breadcrumbs

Three tables

Hierarchical Names
/net/ucl/www/ipsaras/index.html

B. Ahlgren et al. “A Survey of Information-Centric Networking, IEEE Communications Magazine 2012

Information-Centric Mobility

- Content is the addressable entity
  - Not the host!
- Content is the routing target
  - Not the host!
- Interface to the content is used
  - Not to a socket!
- Content is secured individually
  - Not the communication channel!

No need to keep references of moving nodes

Information Exposure through Names

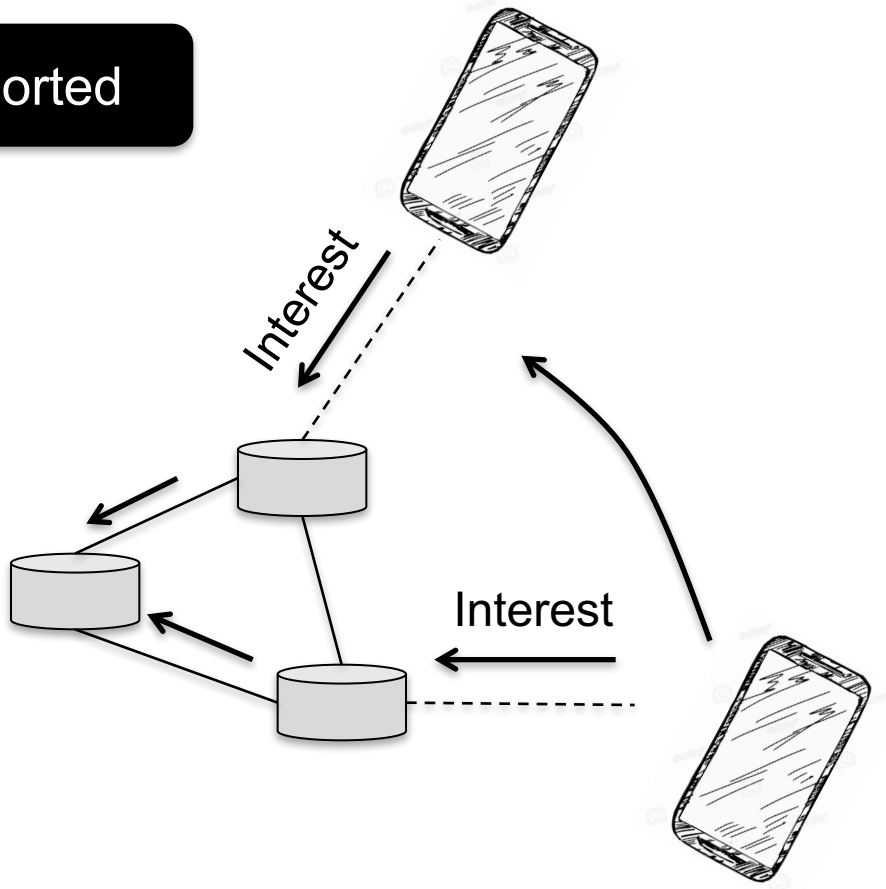
- ICN can enable features not possible with IP
  - Exposure of information through names.

A network-layer naming scheme that enables fine-grained description of the desired processed information

User Mobility in ICN

User mobility is inherently supported

- Interests come from users and therefore can ***follow the right path***
- Very straightforward, no hassle



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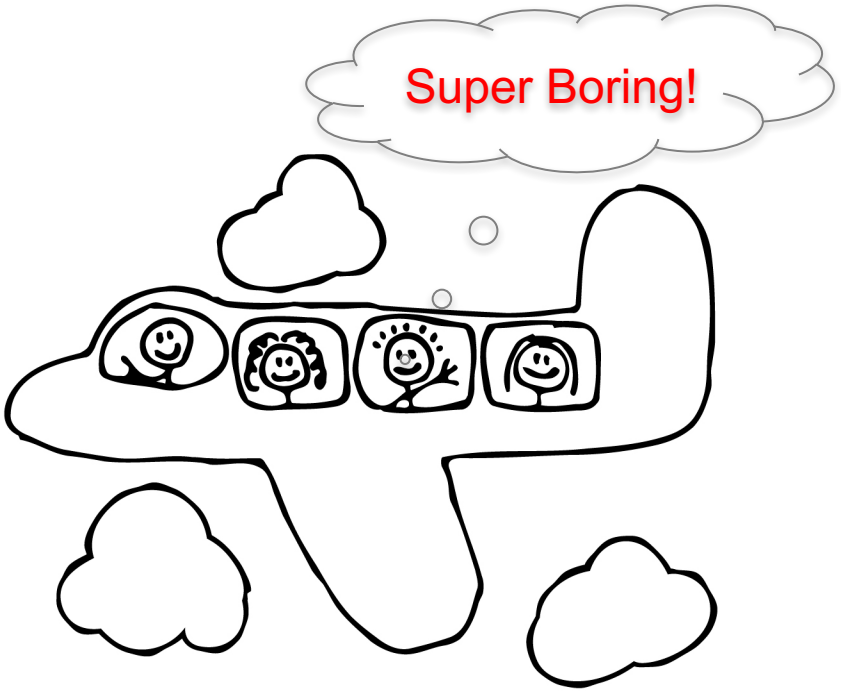
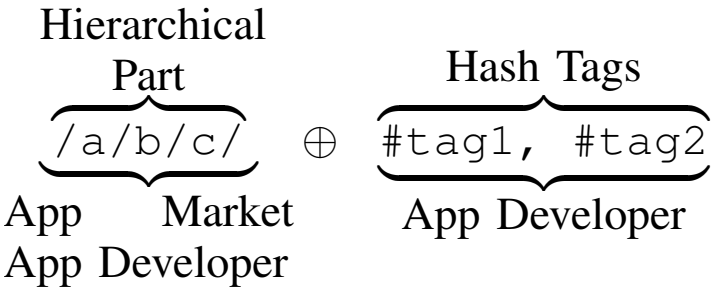


Application-Centric Naming (App IDs)

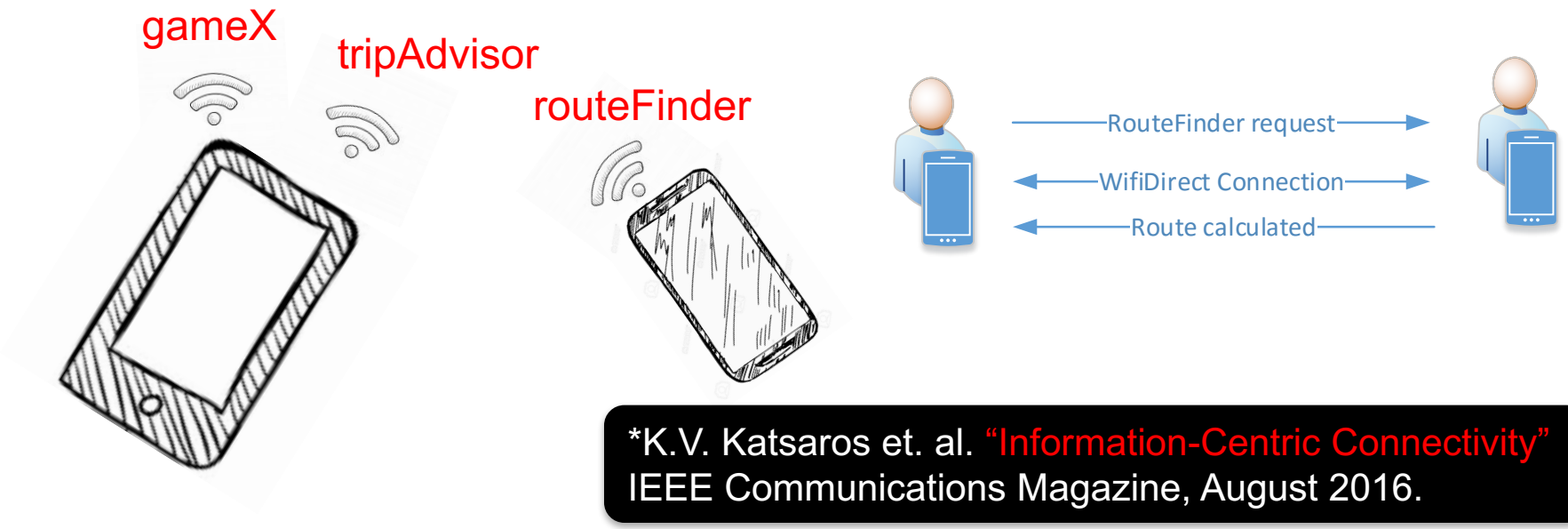
- Needs to support fine-grained description of the desired processed information



- **Fixed part:** *NDN hierarchical naming, longest prefix match*
  - Needs to guarantee compatibility between applications
  - Can define static content: `/NewsApp/politics/`
  - Or invoke computation: `/myTravelAdvisor/Top10Restos`
  - App GUI indicates naming, users do not have to be aware of naming
- **Hashtags:** *free keywords to assist application processing*
  - Enables *partial matching* of responses to requests
  - `/myTravelAdvisor/Top10Restos #userRating; #London; #indian`
  - `/routeFinder/tube #euston; #waterloo`

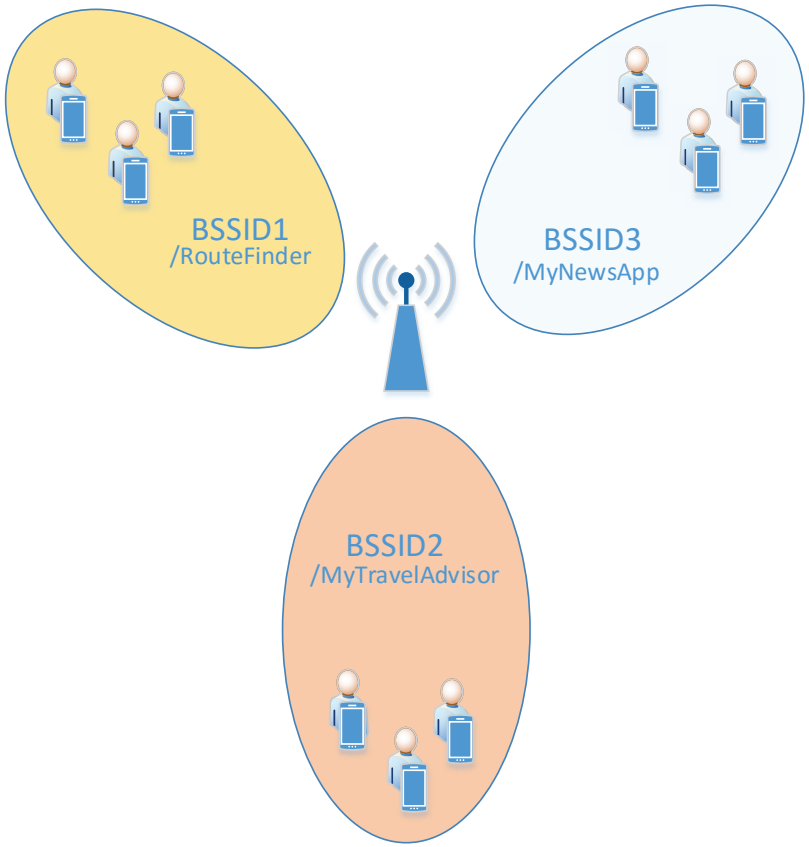
Application-Centric Connectivity

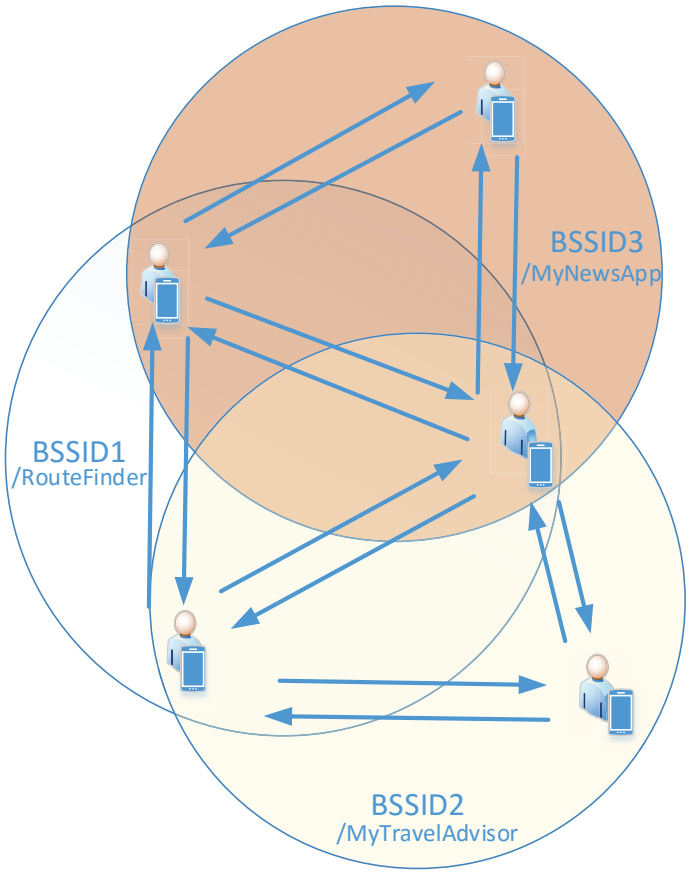
- Application-specific 802.11 broadcast domains, through Basic Service Set(s), BSSs
  - Need a “hook” between BSS and the corresponding application
  - Every KEBAPP application advertises its own SSID, through *WiFi Direct Groups*
  - *WiFi Neighbour-Awareness Networking (NAN)* can find applications behind BSSs – also optimised for energy efficiency



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

AP-assisted and D2D operation





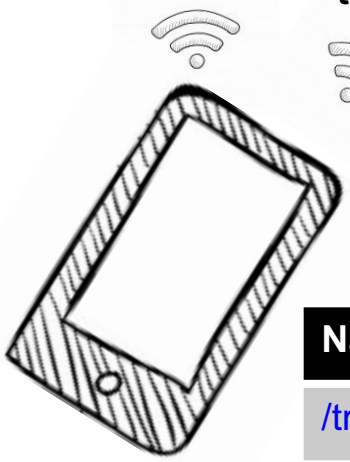
Information-Centric Forwarding

- We build on a modified version of NDN
- Forward messages to single-hop broadcasting (BSS) domains
- Single-hop operation

❑ *Broadcast domains are considered as node interfaces*
❑ FIB is populated with neighbouring BSSIDs

gameX

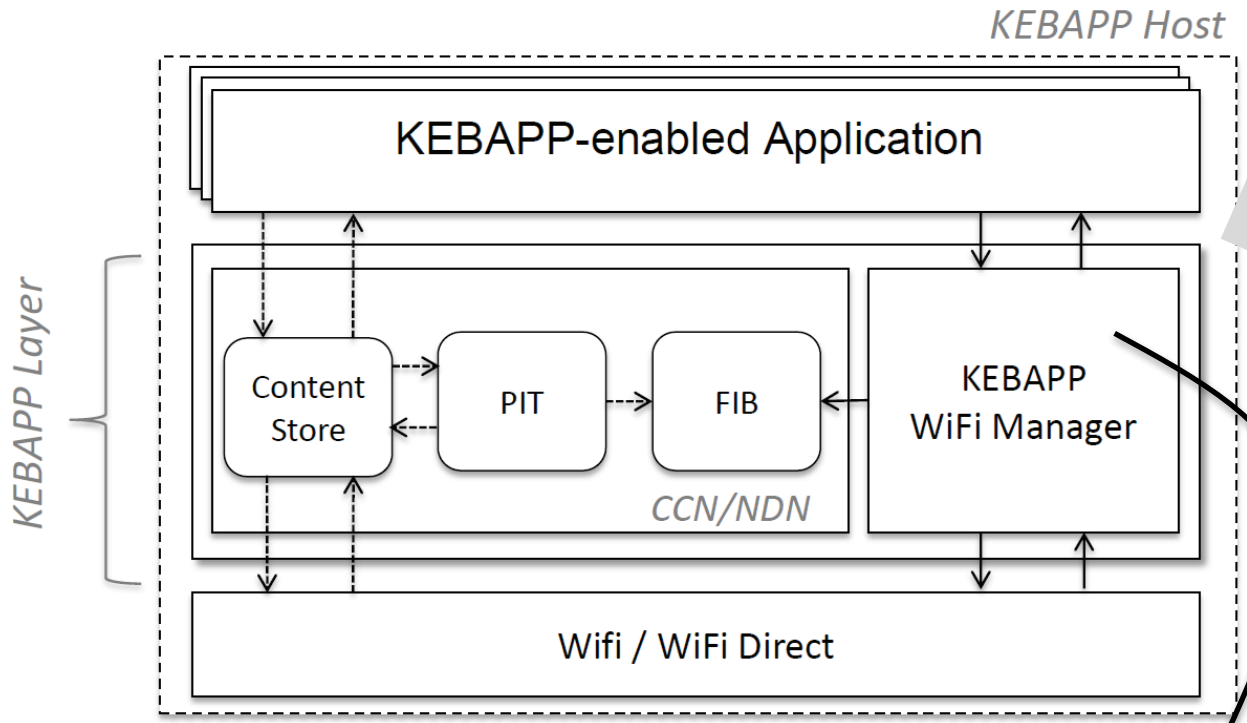
tripAdvisor



Name Prefix	BSSID	*if*
/travel/routeFinder #x	routeFinder	#1

Name Prefix	BSSID	*if*
/travel/tripAdvisor #x #y	tripAdvisor	#1
/gaming/gameX #z	gameX	#2

routeFinder



WiFi Manager populates FIB with hierarchical name advertised by SSID

BSSIDs are the new interfaces

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2a3b69e43f9bd48937	/d/e/f#t3#t4

PIT

In	Name	Out
Internal face #1	/a/b/c#t1#t2	BSSID1
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FIB

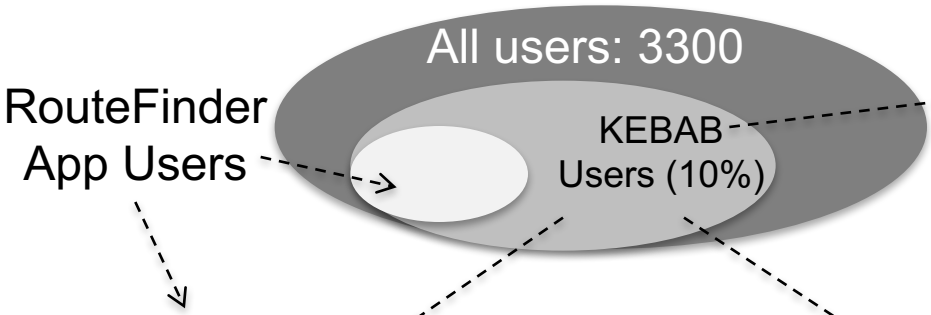
Prefix	BSSID	Face
/a/b/c	BSSID1	Internal face #1
/d/e/f	BSSID2	Internal face #2

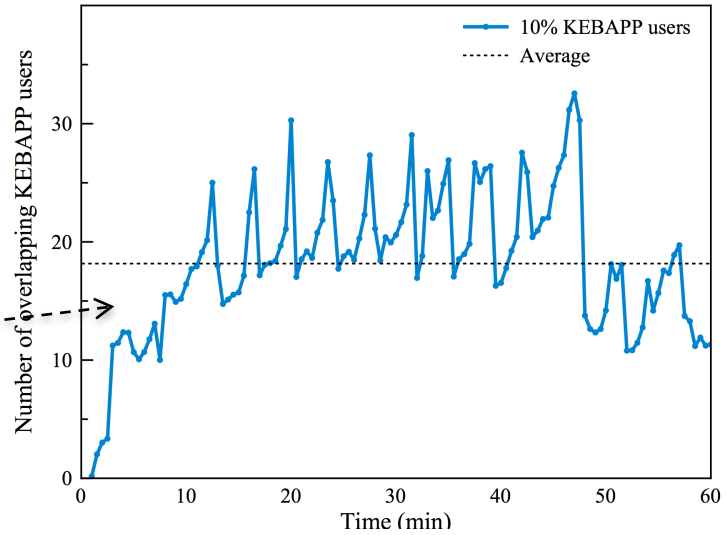
One PIT entry per request

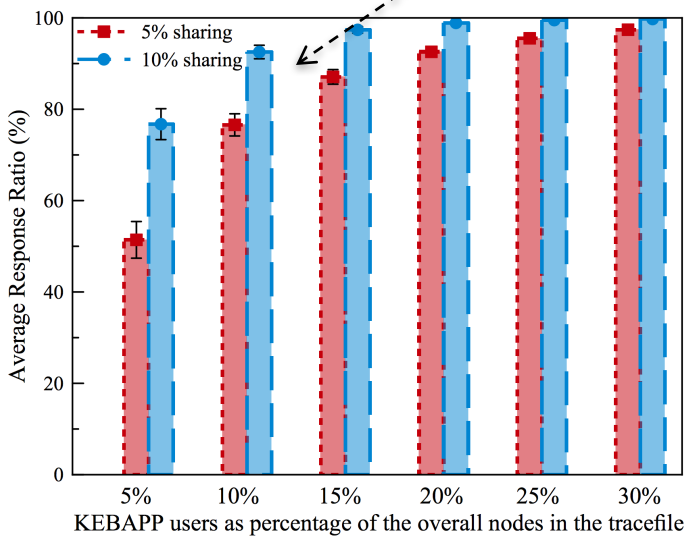
Server part of app
`internalFace` entry links BSSID to specific app that listens to this SSID.

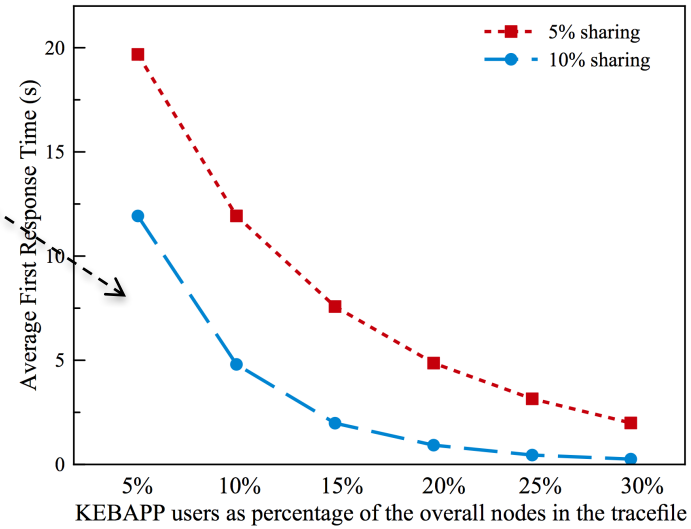
Feasibility – RouteFinder App

Setup
Mobility trace from 3300 users in a Stockholm subway station throughout one hour

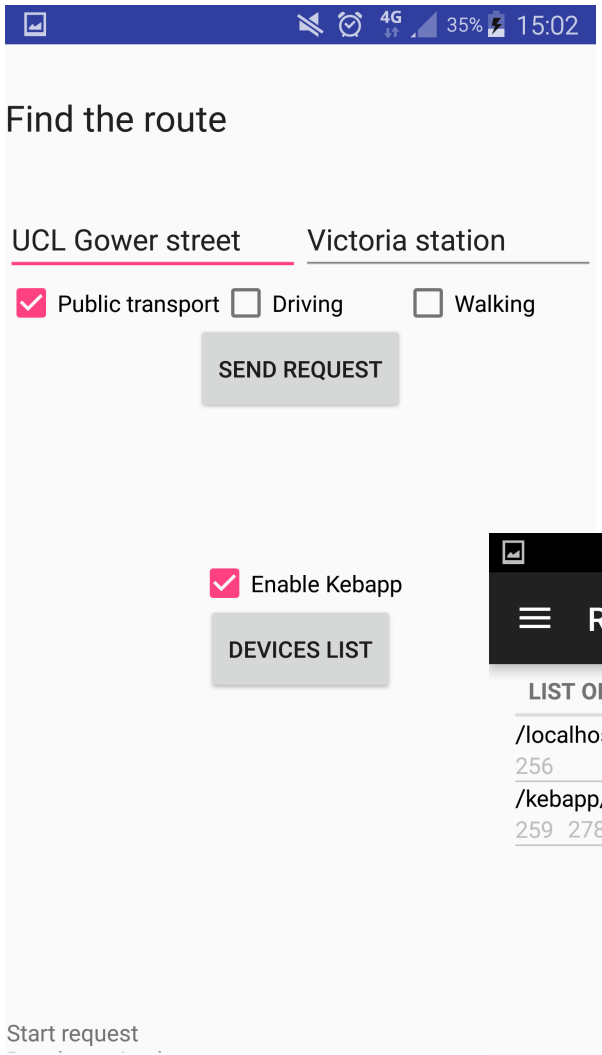


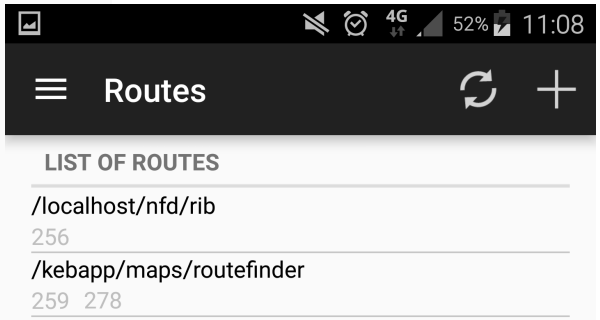


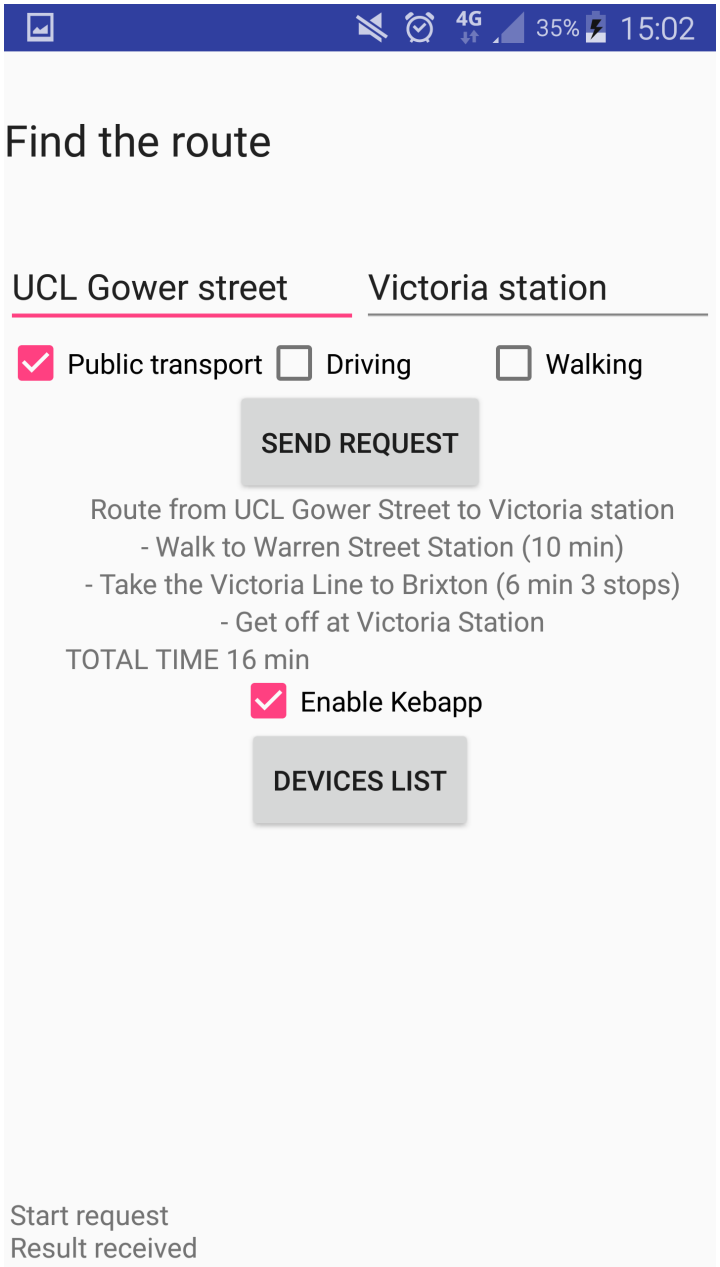




Route Finder App



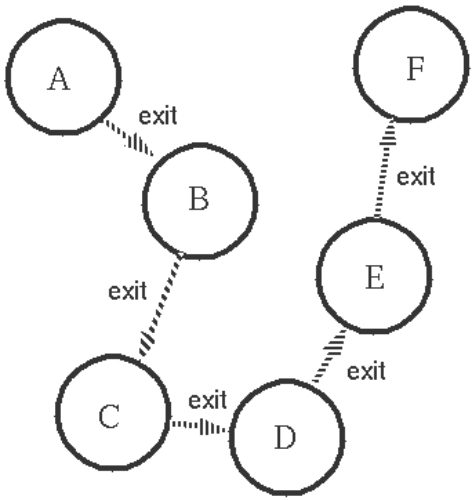




Taxi Share App / Carpooling

- Group commuters into taxis/vehicles locally
  - User 1 wants to travel from A – C
  - User 2 wants to travel from A – B, where B is along the route A – C
  - User 3 travels from A – D and so on
- Can't think of many good reasons

not to do this locally...

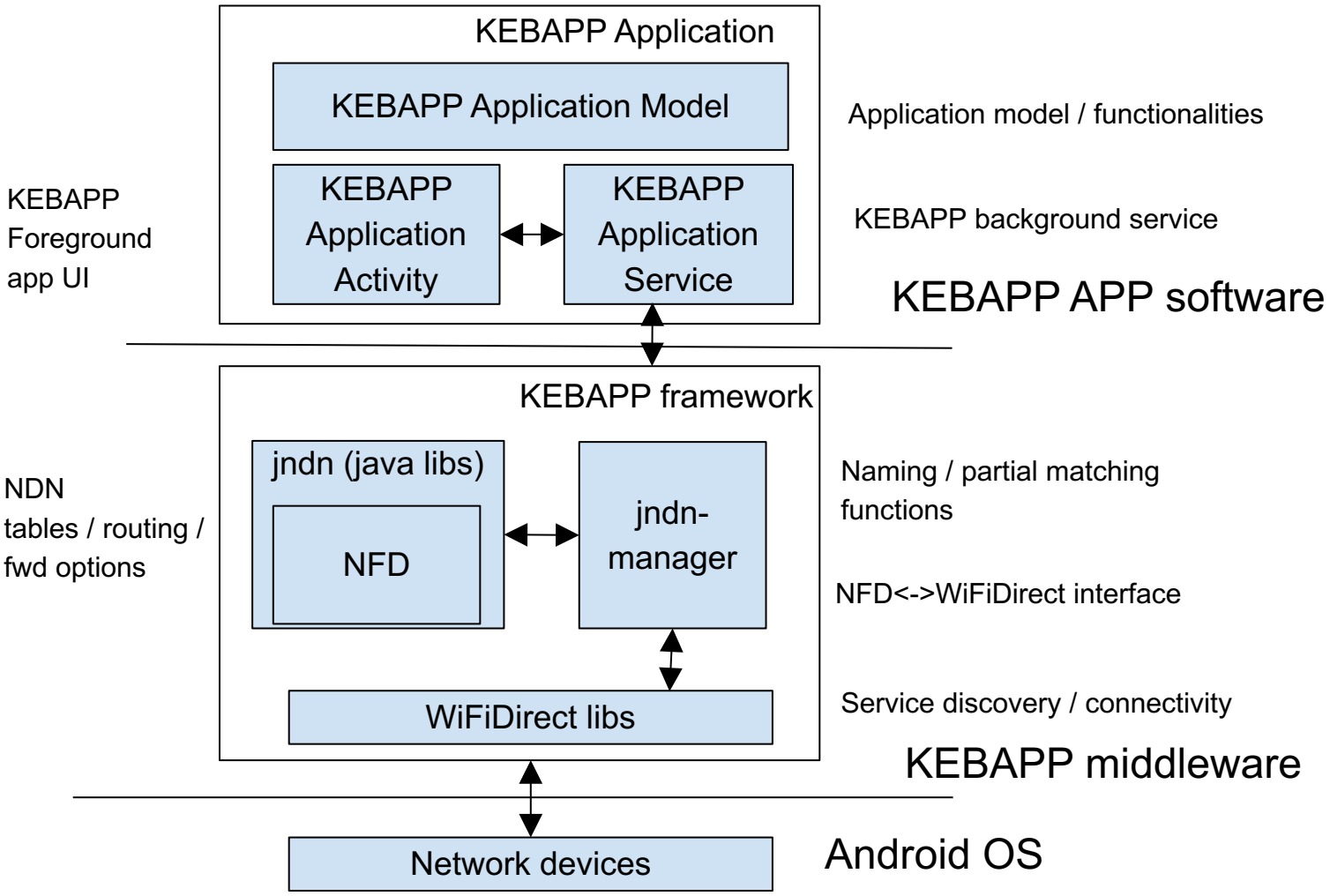


Vision: An Edge ICN IoT Platform based on Information-Centric Connectivity

- The long-term plan is to develop a platform for IoT applications
  - users can build applications or applets
  - API should be lightweight and easy to use, e.g., IFTTT-like
- Some applications already implemented in Raspberry PIs – plan to extend to WiFi APs through OpenWRT

How to implement KEBAPP?

Android implementation components



Thanks!

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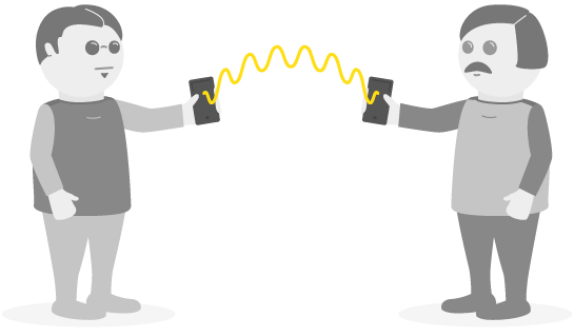
BACKUP SLIDES

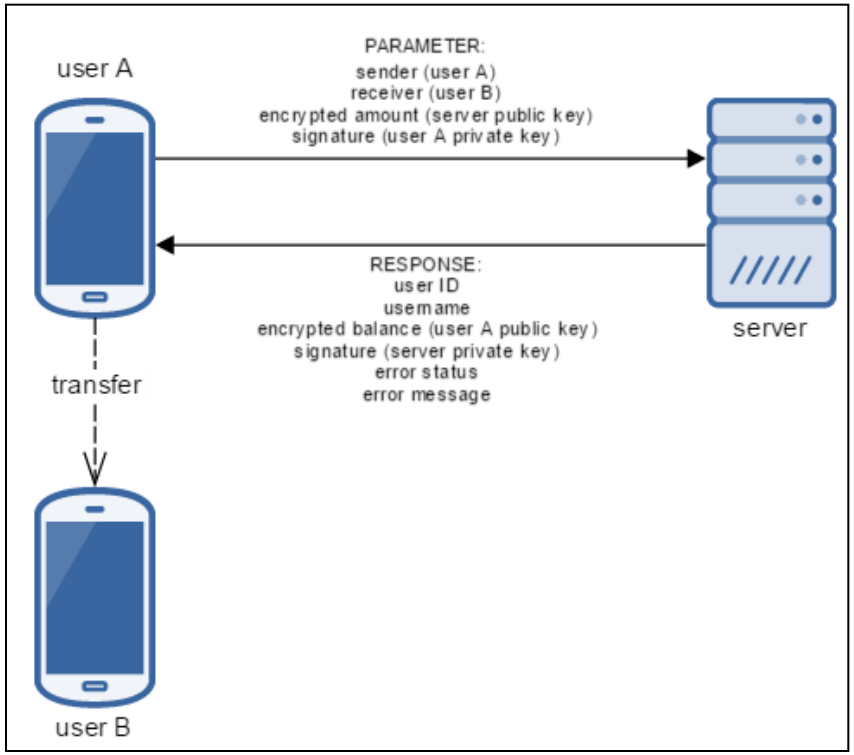
Incentives through Micropayments



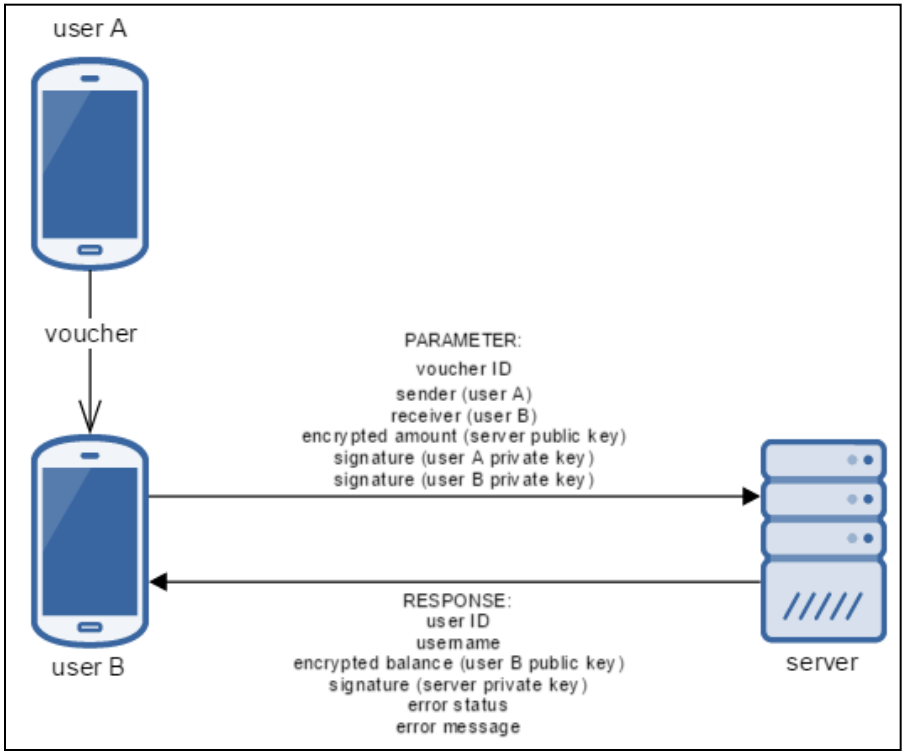
- Looks like a good fit for a *virtual currency*
- Blockchain ok to use when users are online
  - Trickier for offline transactions
- We looked into offline micro-payment systems
  - Main finding: there aren't many :)
    - Any pointers greatly appreciated
  - Two good reasons for that
    - Difficult to design
    - Not many existing applications require offline micropayments

Online vs Offline Micropayment

Online Mode



Offline Micropayment



- *Central trusted authority issues certificates*
- *Certificates trusted by nodes who pay with vouchers*
- *Vouchers later validated when users get back online*