# UMOBILE WP4

## Review I

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# UMOBILE

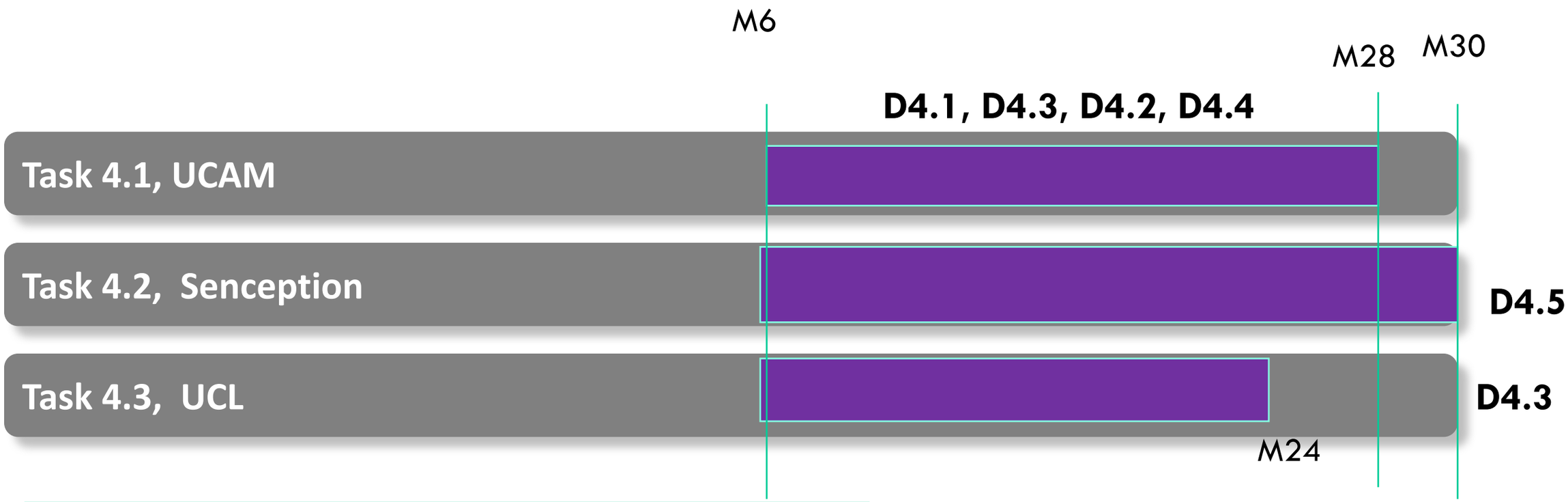
## WP4 Goals - Status

- The main objective of WP4 is to enhance the UMOBILE architecture in terms of QoS/QoE and enable solutions that take advantage of the unique features of the developed architecture. This WP will use the architecture developed during WP3 to provide a set of services.

| Goal | Status (2016.07) |
|---|---|
| O4.1: To enable services which fully exploit the inherent opportunistic nature of communications. | First version of Persense Mobile Light released in May 2016; roaming contextualization (Wi-Fi. Wi-Fi Direct, Bluetooth) - task 4.2 |
| O4.2: To enable the “Internet” experience as many people know it, with apps such as the Web, e-mail. Challenge: intermittent connectivity and/or adjusting to QoE. | |
| O4.3: to develop mechanisms for processing of sensor data through context understanding. | PerSense Mobile Light |
| O4.4: to provide different levels of QoS depending on the needs of each user/network ranging from less-than-best-effort to guaranteed services. | Deliverable 4.4 (not in the scope of the period) |

# UMOBILE

## WP4 Roadmap, Deliverables, Milestones




| Deliverables (editor, Senception) |
|---|
| D4.1: Flowlet congestion control , initial report (M18) |
| D4.2: Flowlet congestion control, final report (M30) |
| D4.3: Name-based replication priorities (M24) |
| D4.4: Set of QoS interfaces and algorithms (M28) |
| D4.5: Report on data collection and inference models (M30) |

| Milestones |
|---|
| MS7: QoS interfaces and mechanisms for data handling (M30) |
| MS8: Flowlet congestion control developed (specs, M30) |

# WP4

## List of Main Achievements

- **Deliverables (1)**
  - D4.1 : Flowlet Congestion Control – Initial Report
- **Scientific Papers (4)**
- A. Sathiaseelan, L. Wang, A. Aucinas, G. Tyson and J. Crowcroft: SCANDEX: Service Centric Networking for Challenged Decentralised Networks, Proceedings of the ACM Mobisys Workshop on Do-it- yourself Networking: An Interdisciplinary Approach, 2015.
- Wang, Liang, et al. "Pro-Diluvian: Understanding Scoped-Flooding for Content Discovery in Information-Centric Networking." Proceedings of the 2nd International Conference on Information-Centric Networking. ACM, 2015
- Rute C. Sofia and Paulo Mendes, A Characterization Study of Human Wireless Footprints based on non-intrusive Pervasive Sensing (2015), UNDER SUBMISSION (2016)
- A. Lertsinsrubtavee, L. Wang, A. Sathiaseelan, N. Weshsuwannarugs, A. Tunpan, K. Kanchanasut, J. Crowcroft , "Understanding Internet Usage and Network Locality in a Rural Community Wireless Mesh Network", Proceeding of the 11th Asian Internet Enginee
- **Software (1)**
  - PerSense Mobile Light
- **Demos (1)**
  - PerSense Mobile Light, Mobicom 2016, app contest, 04.10.2016 NY, USA

# Tasks and Main Achievements

## Task 4.1

M6-M28

**Providing different levels of QoS and flow control (UCAM, DUTH, UCL)**

**Focus:** Support for eterogeneous needs of QoS levels

- Guarantees with intermittent connectivity

INRPP – UCL

QoS in Service Migration - UCAM

Demo

## Task 4.2

M6-M30

**Data collection and contextual inference (SENCEPTION, AFA, DUTH)**

**Focus**: data capture and data processing in an efficient way, based on opportunistic and challenged environments

PerSense Mobile Light

Demo

## Task 4.3

**M6-M24**

**Name-Based Replication Priorities (UCL, SENCEPTION)**

**Focus**: support of mobile name-based replication

NREP



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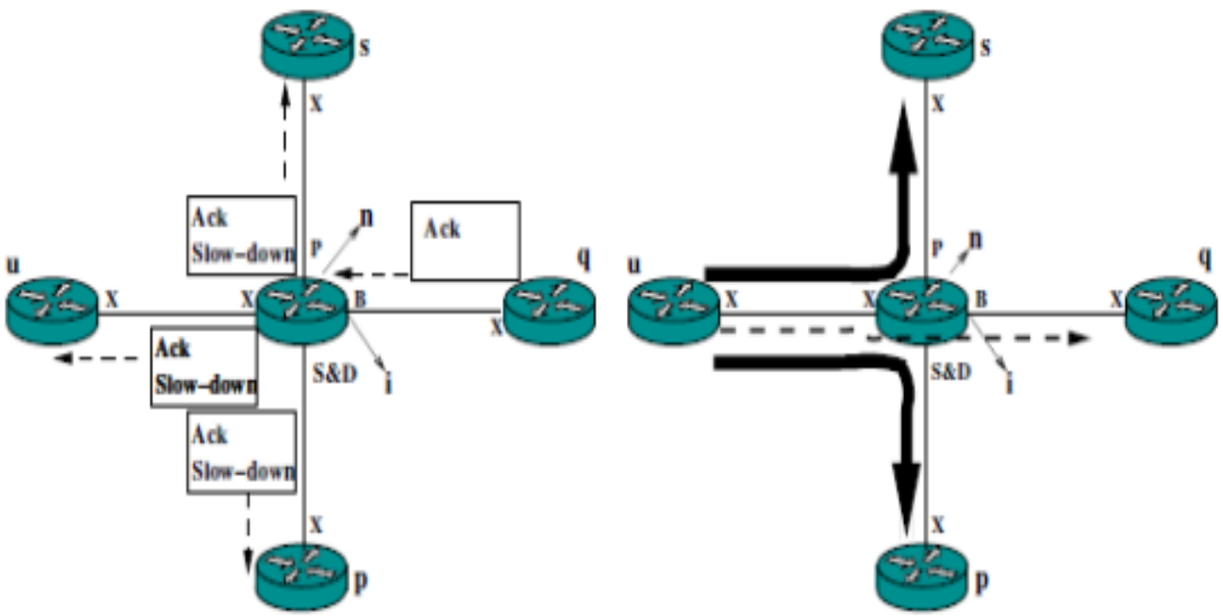
# Congestion Control in UMOBILE: the Framework based on In-Network Resource Pooling Model

# INRP Roadmap

## Phase I – validation in IP – D4.1

- When cache is full INRPP notifies upstream router through Acks and starts Closed-Loop (CL) with previous node.
- Sender slows-down rate to ACK pace.
- The CL state is transmitted upstream until it reaches the TCP sender, that slows-down to ACK pace as well when all caches are fulll.



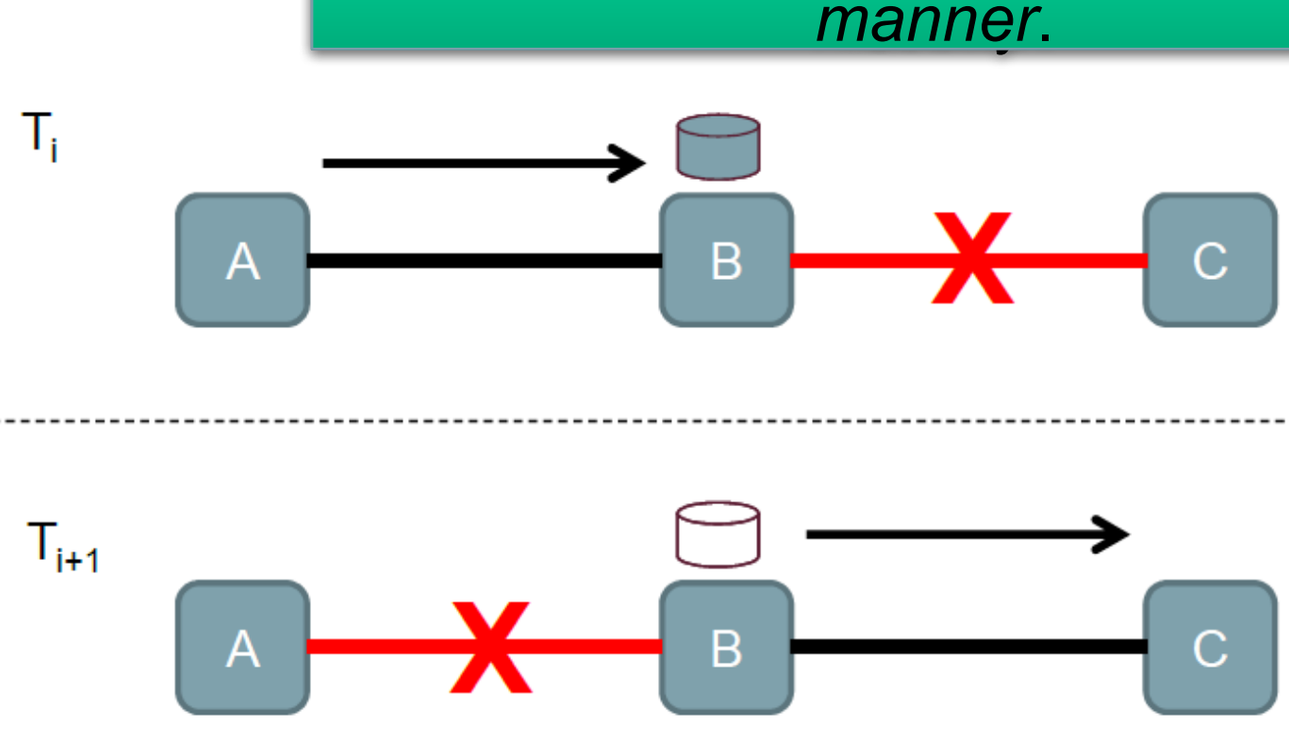

## Phase 2: ICN/NDN – D4.2

- INRPP takes advantage of the built-in abstractions(transparencies) provided by the NDN.
- INRPP NDN design principles:
  - We assume Interest packets and Data or Content chunks generated by receivers and senders, respectively.
  - Data receivers will request data at the application rate, and for bulk data transfers an initial processor sharing rate will have to be set.
  - After receiving the first few chunks of data, the receiver will continuously adjust its requesting rate to the incoming data rate.
  - Applications will slow down and enter closed-loop transmission.
  - Routers can detect congestion based incoming interests per interface.

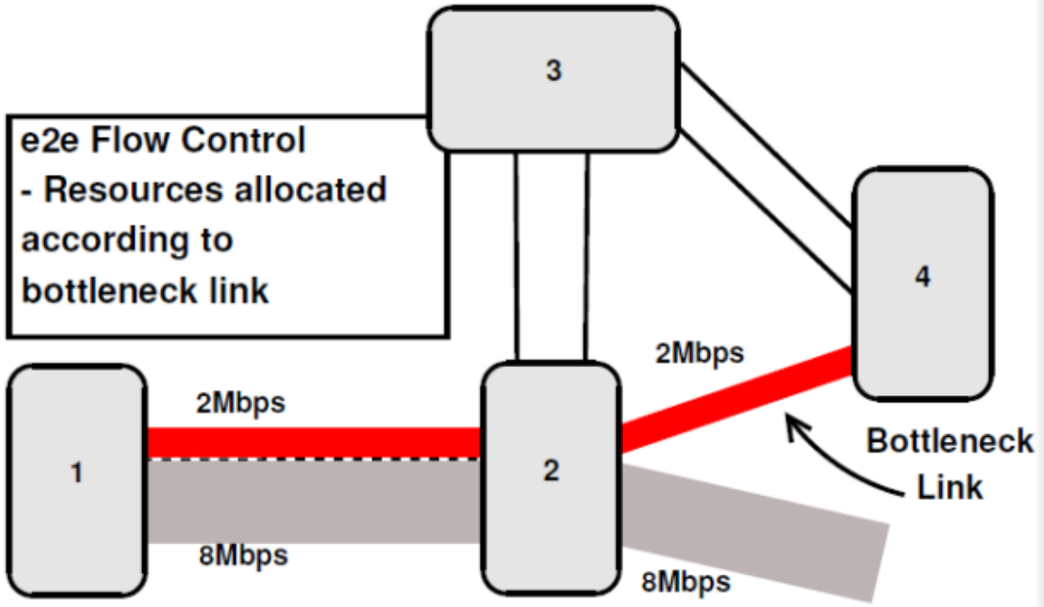
# Why INRP?

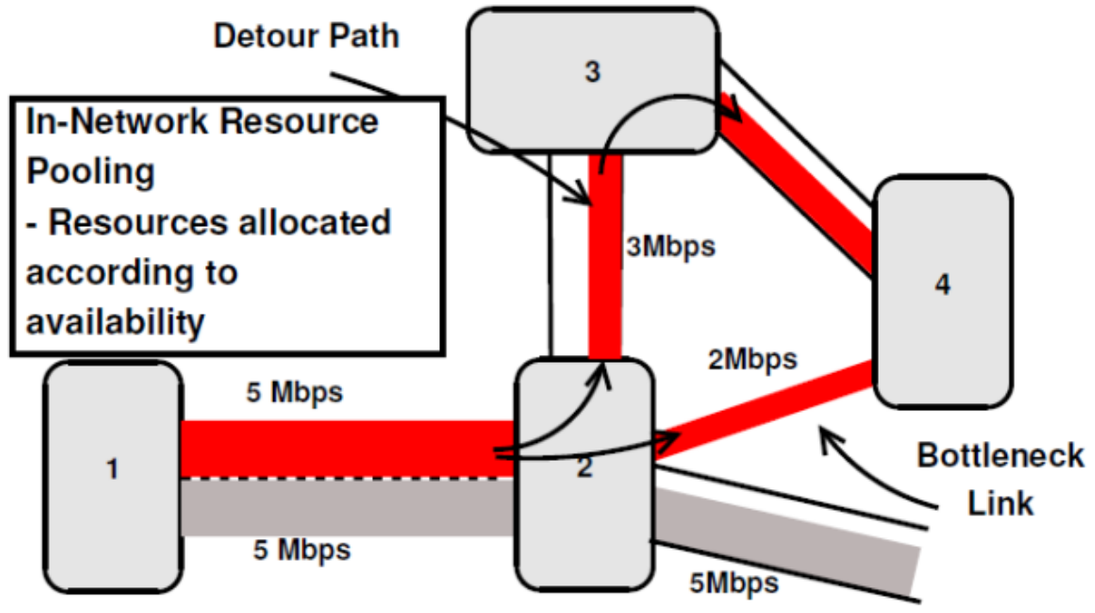
- The presence of ubiquitous packet caches enables more efficient usage of resources by enabling pooling of subpaths.

3. Exploit all available (sub-)paths making decisions on a *hop-by-hop manner*.



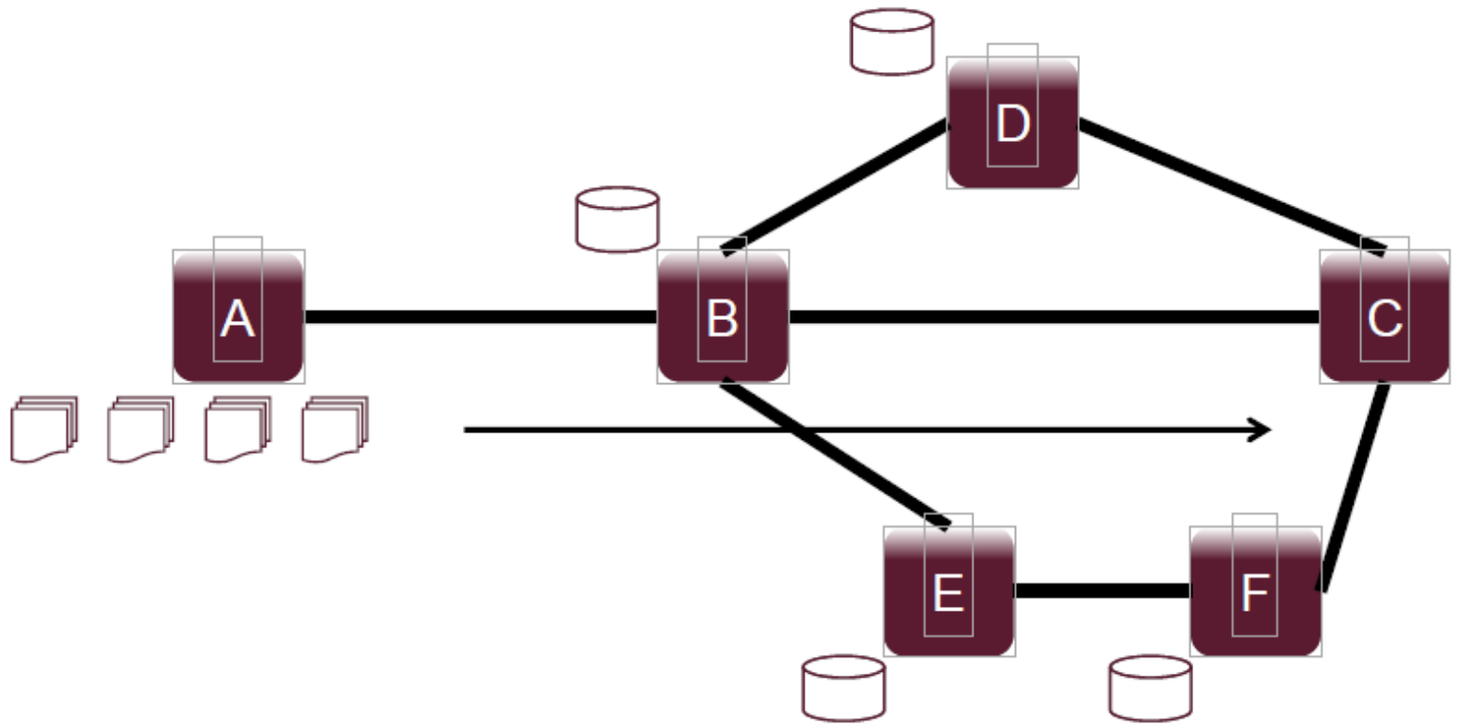
# Resource Pooling



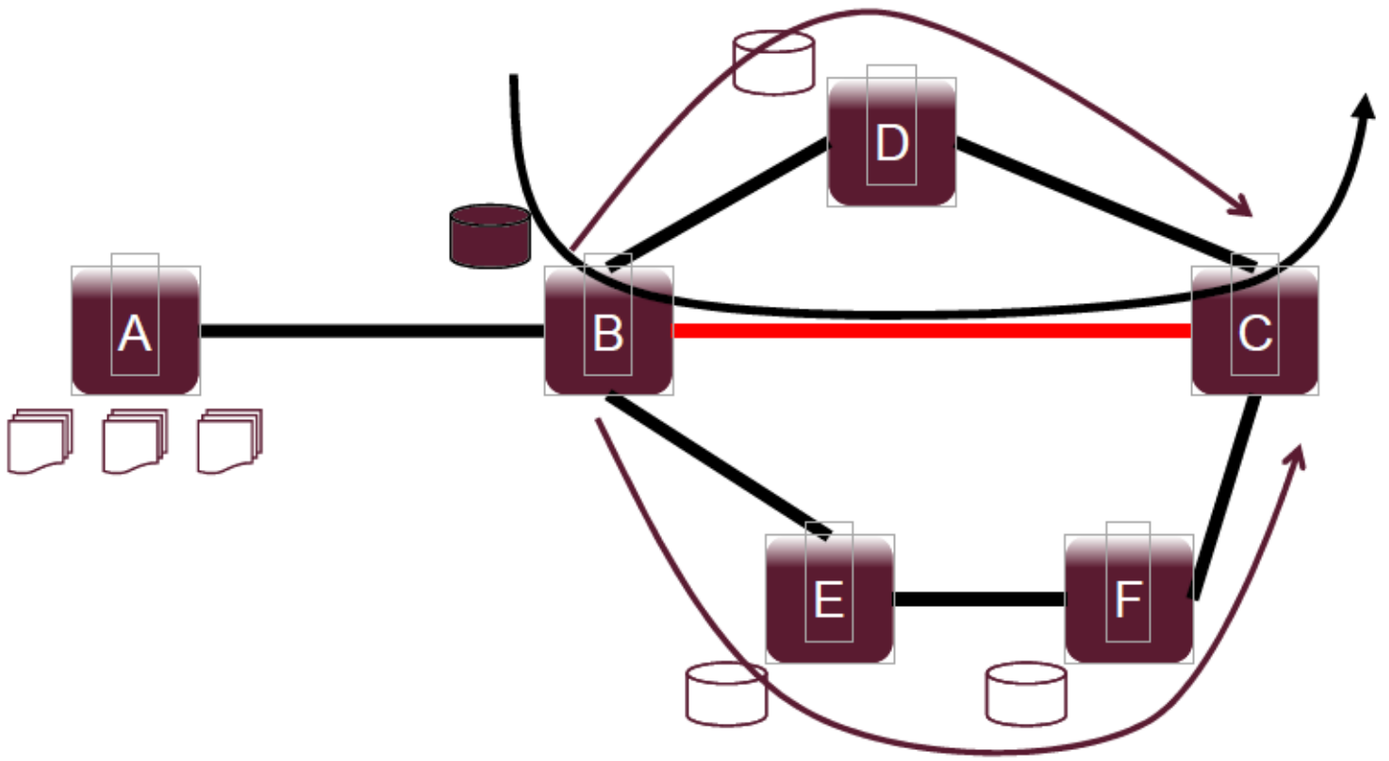
# 3-Phase Operation

- **Push-data phase** – Open-Loop System
  - Processor-sharing, RCP-like transmission
  - Open loop system – senders send even more than what they have received requests for
    - Push data as far and as quickly as possible



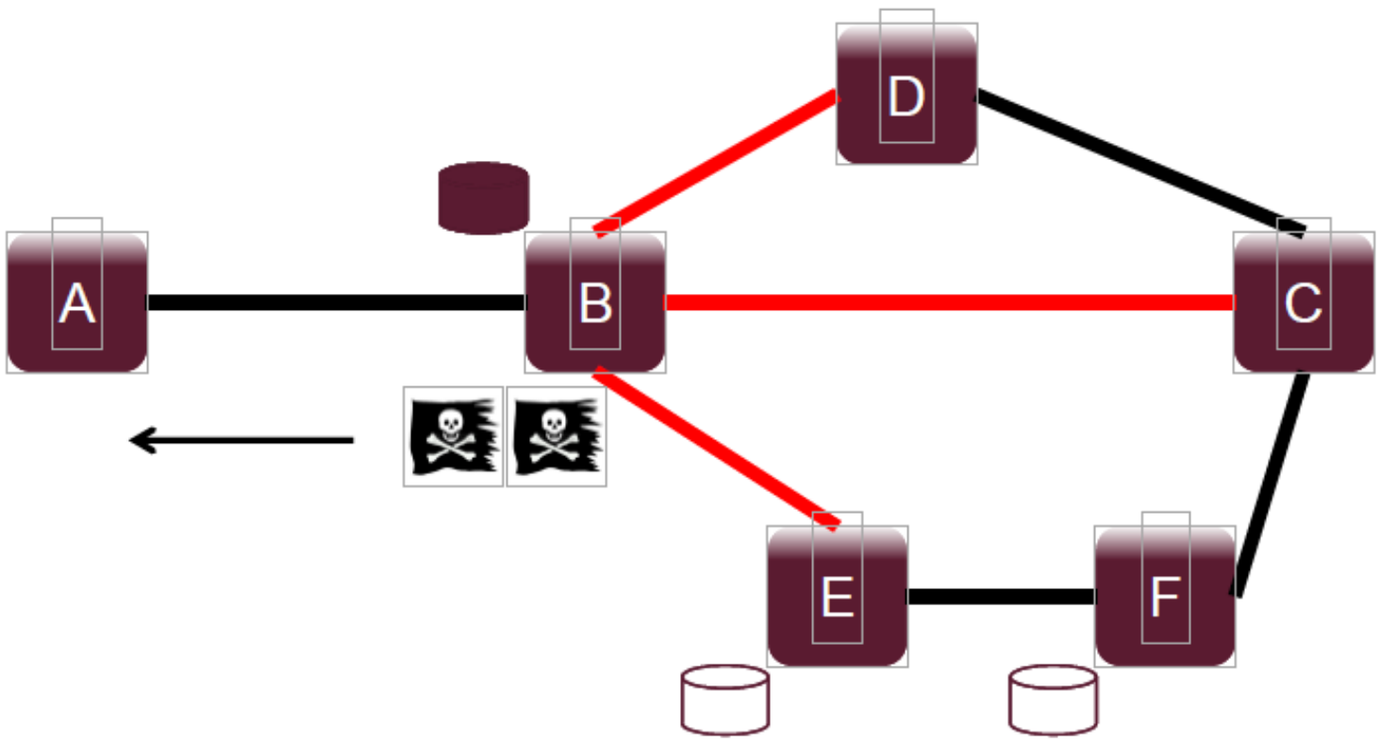
# 3-Phase Operation

- **Cache & Detour phase**
  - Every router monitors incoming *Requests*
  - When demand is expected to exceed supply, the local router tries to find alternative paths to detour
  - In the meantime traffic in excess (if any) is cached locally

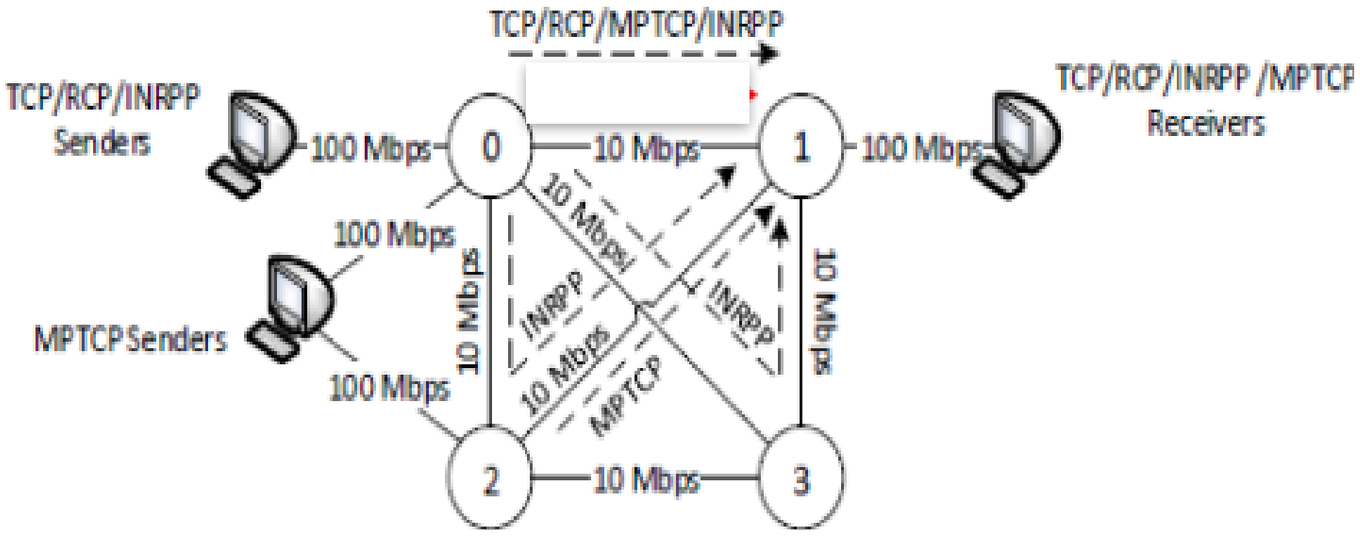


# 3-Phase Operation

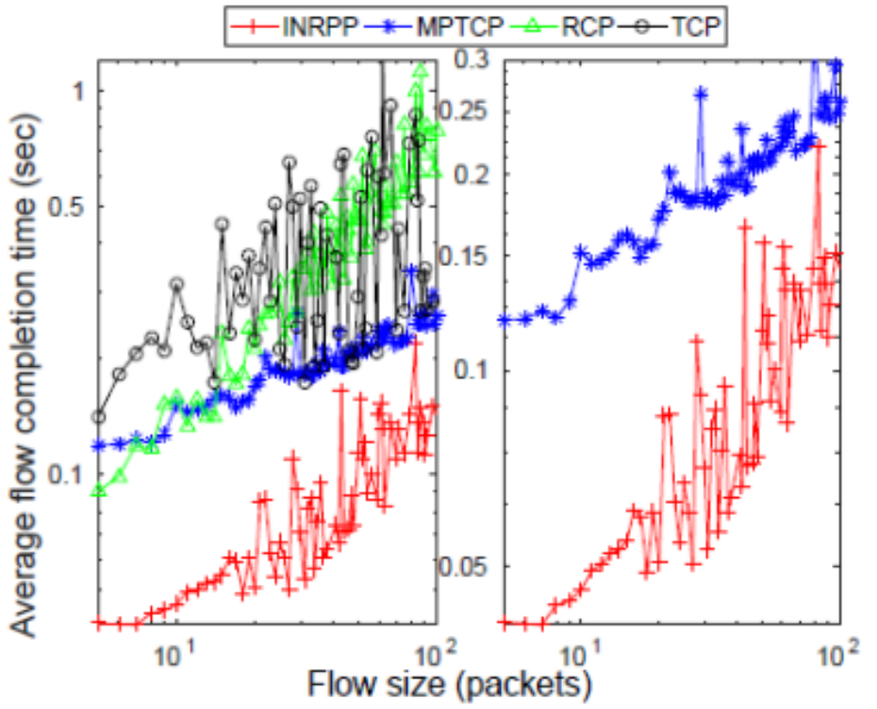
- **Backpressure phase** – Closed-Loop System
  - If alternative paths do not exist or are equally congested:
    - Pace Requests
    - Send notification upstream to slow down and enter closed-loop transmission



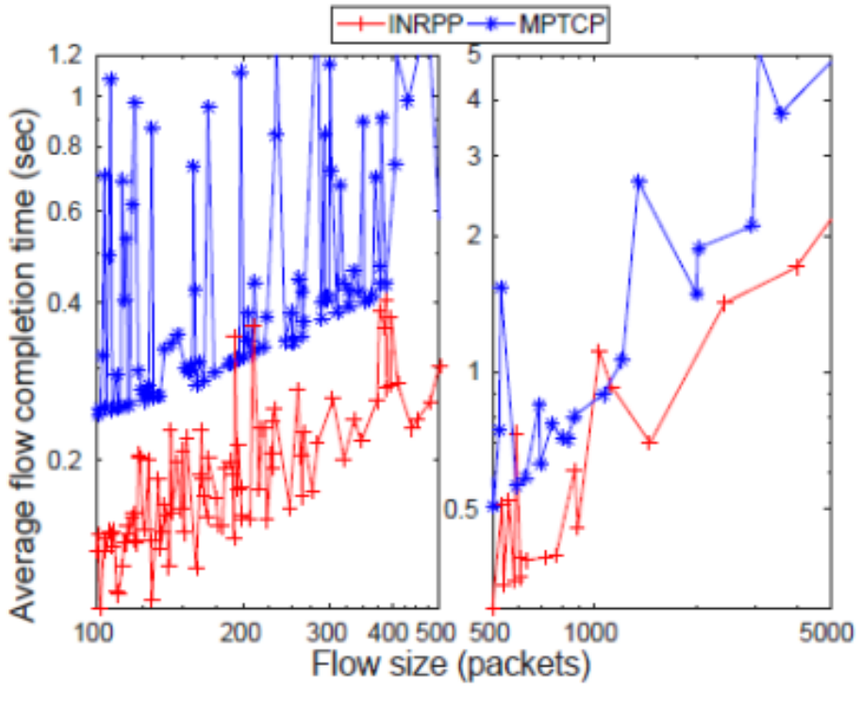
# Some Initial Results




Simple multihomed topology scenario

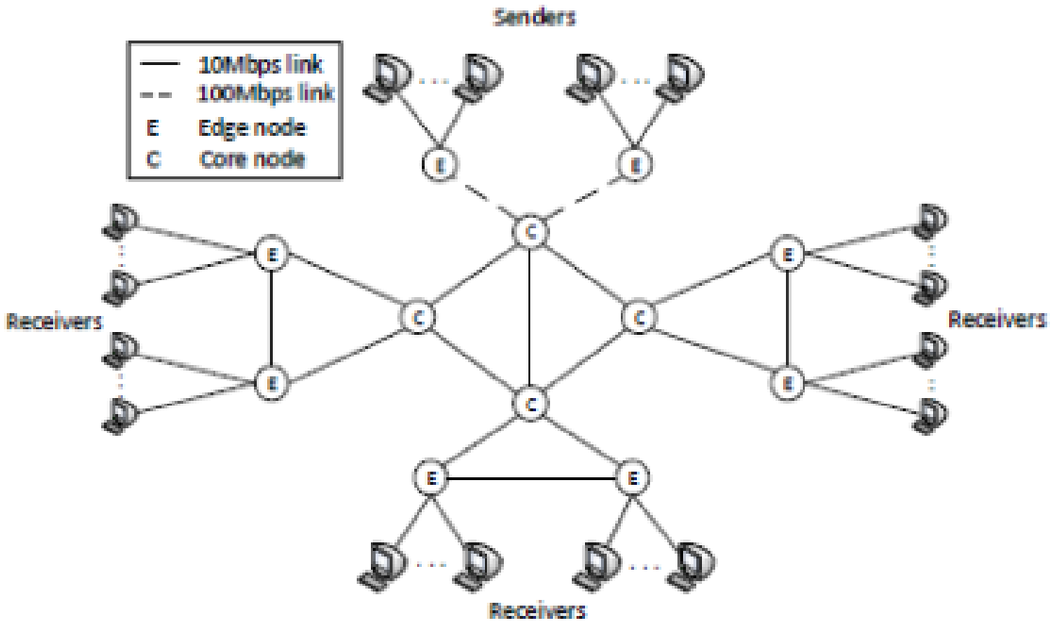



(a) AFCT for $E[L] = 30$

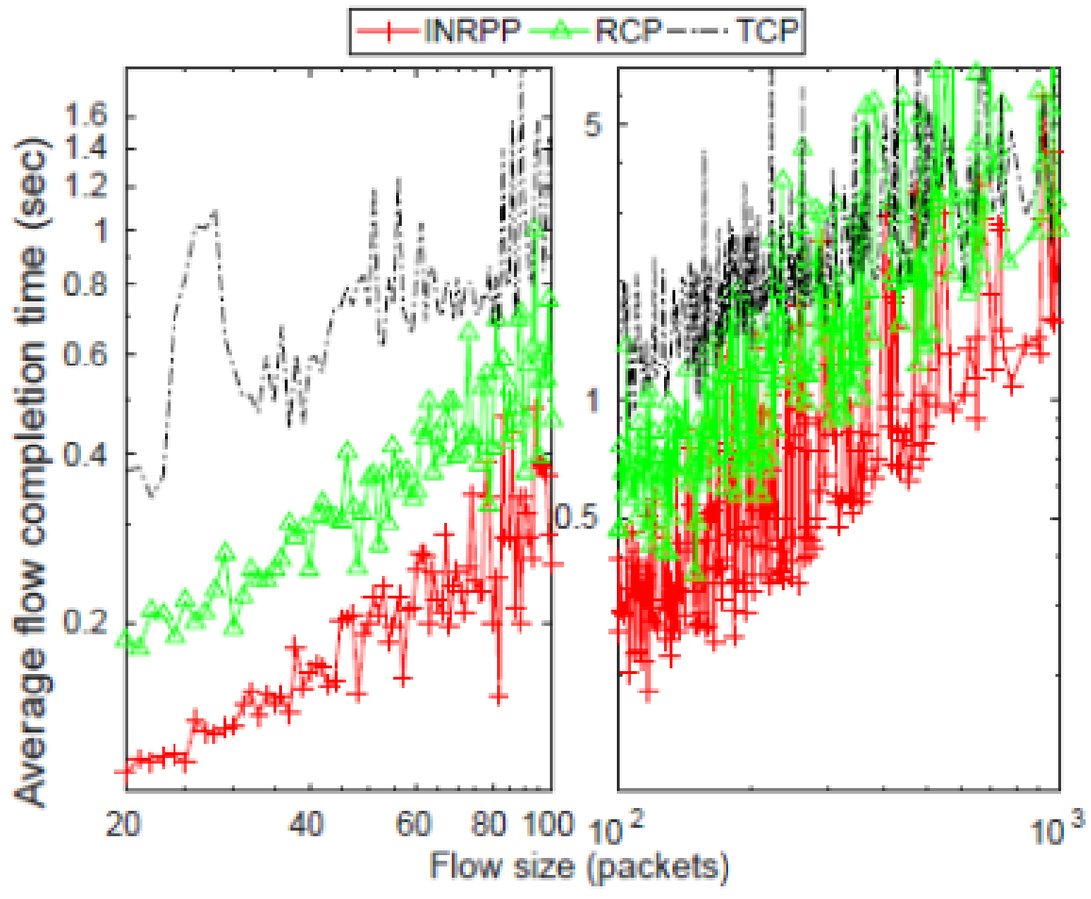



(b) AFCT for $E[L] = 500$

# Some Initial Results




Multi-domain topology scenario



# Congestion Control Phase 2 (D4.2)

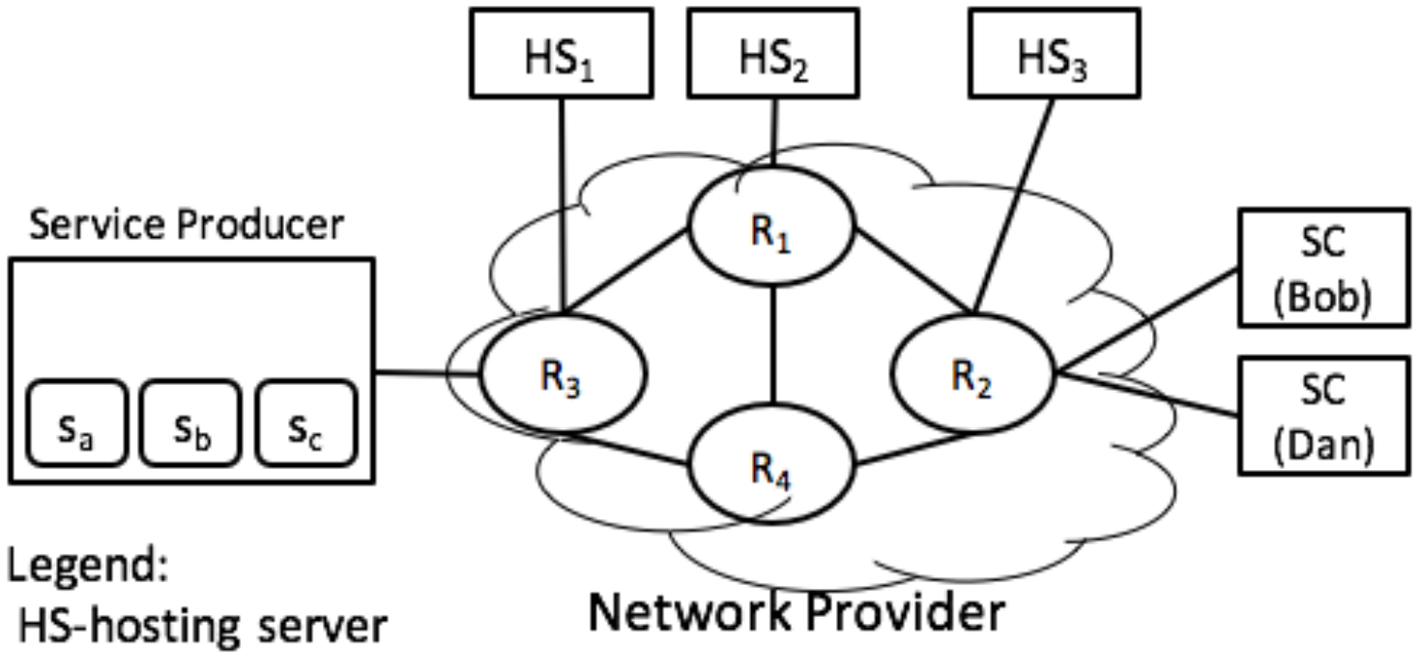
- **INRPP over ICN/NDN networks**
  - Known issues:
    - Push services: Push services may not maintain 1-to-1 flow balance of interests and data chunks, which difficults rate control based on interests regulation.
    - Wireless links: We cannot consider the capacity of a link as known and constant and disconnections or packet loss can be an issue.
    - DTN opportunistic links: DTN tunnelling hinders the implementation of the INRPP
    - Out-of-order delivery: out-of-order delivery is an important issue that we will need to be dealt with, in case of detouring path with different characteristics
    - Pull multicast: On path caching allows router's cache directly response without adding more traffic. We can take benefit from this issue, but we will need to better explore possible issues in terms of congestion control and fairness.

# QoS and Service Migration - UCAM

UNIVERSITY OF CAMBRIDGE

# Proposed QoS Model






Legend:
HS-hosting server
$s_a$, $s_b$, $s_c$- services (applications) with different QoS requirements.
$R_i$- routers SC- service consumer

- There are different business models for service provisioning.
- We assume a business model with four stakeholders:
  - Service Producer (SP)
  - Service Distributor (SD)
  - Internet Service Provider (ISP)
  - Service Consumer (SC)

**Why this model?**

- This is one of the simplest but realistic models.
- The network provider is responsible for and in full control of the QoS delivered by the services.
- He/she can deploy QoS mechanisms as needed.
- Commercial network providers also apply this model for VoD service

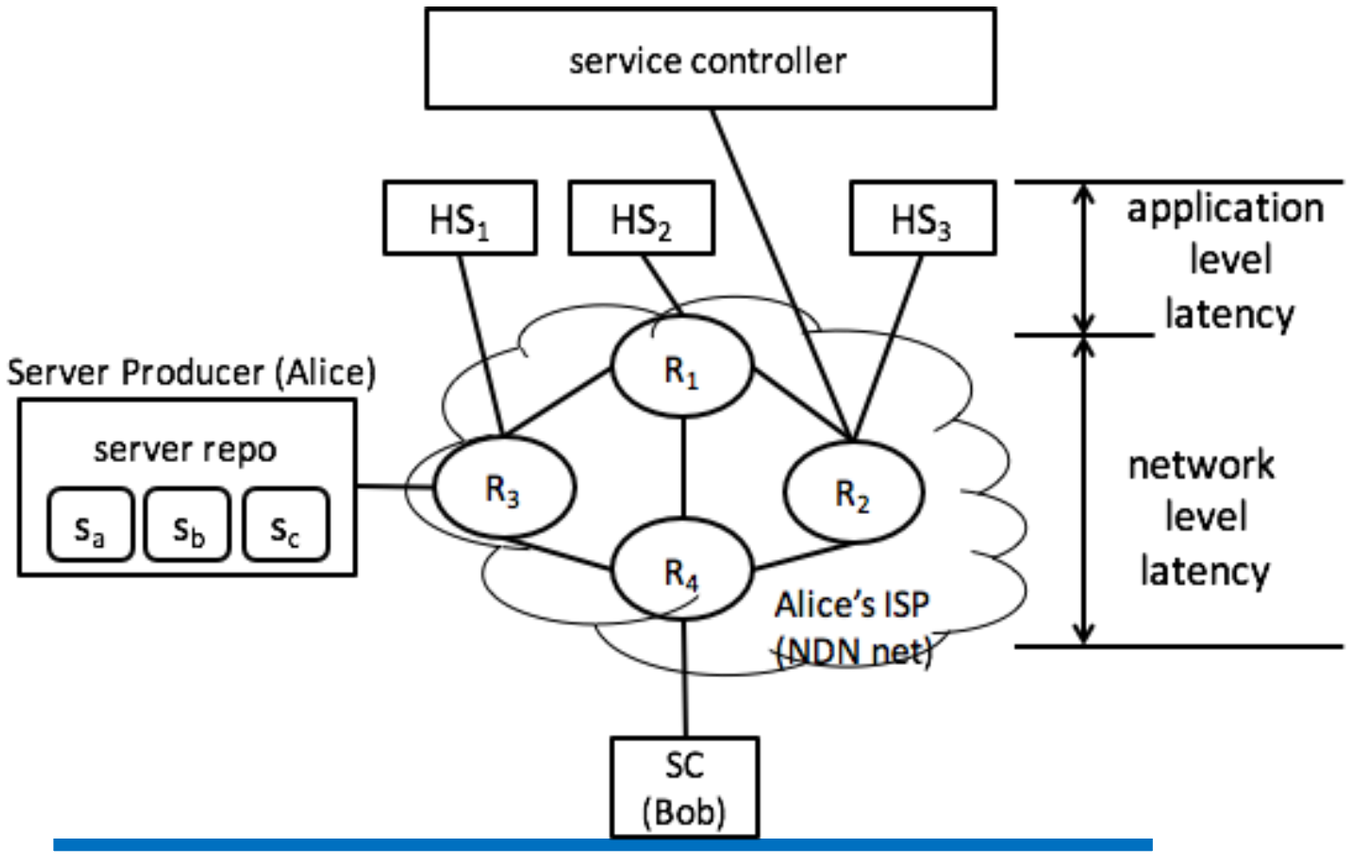
# Relevant QoS Parameters in UMOBILE

- Potential QoS parameters are:
  - Latency
  - Availability
  - Throughput
  - Time to repair (service recovery), etc.
- We are focused (for the time being) on **latency** and **availability**, It seems to be universally relevant.

# Classes of Services and QoS Mechanisms

**Classes of Services**

- **High Priority**
  - Latency: Low, Availability: Guarantee
- **Best effort**
  - Latency: Conventional, Availability: No Guarantee
- **Less than best effort (Explicit Delay Tolerance)**
  - Latency: No Guarantee , Availability: Guarantee



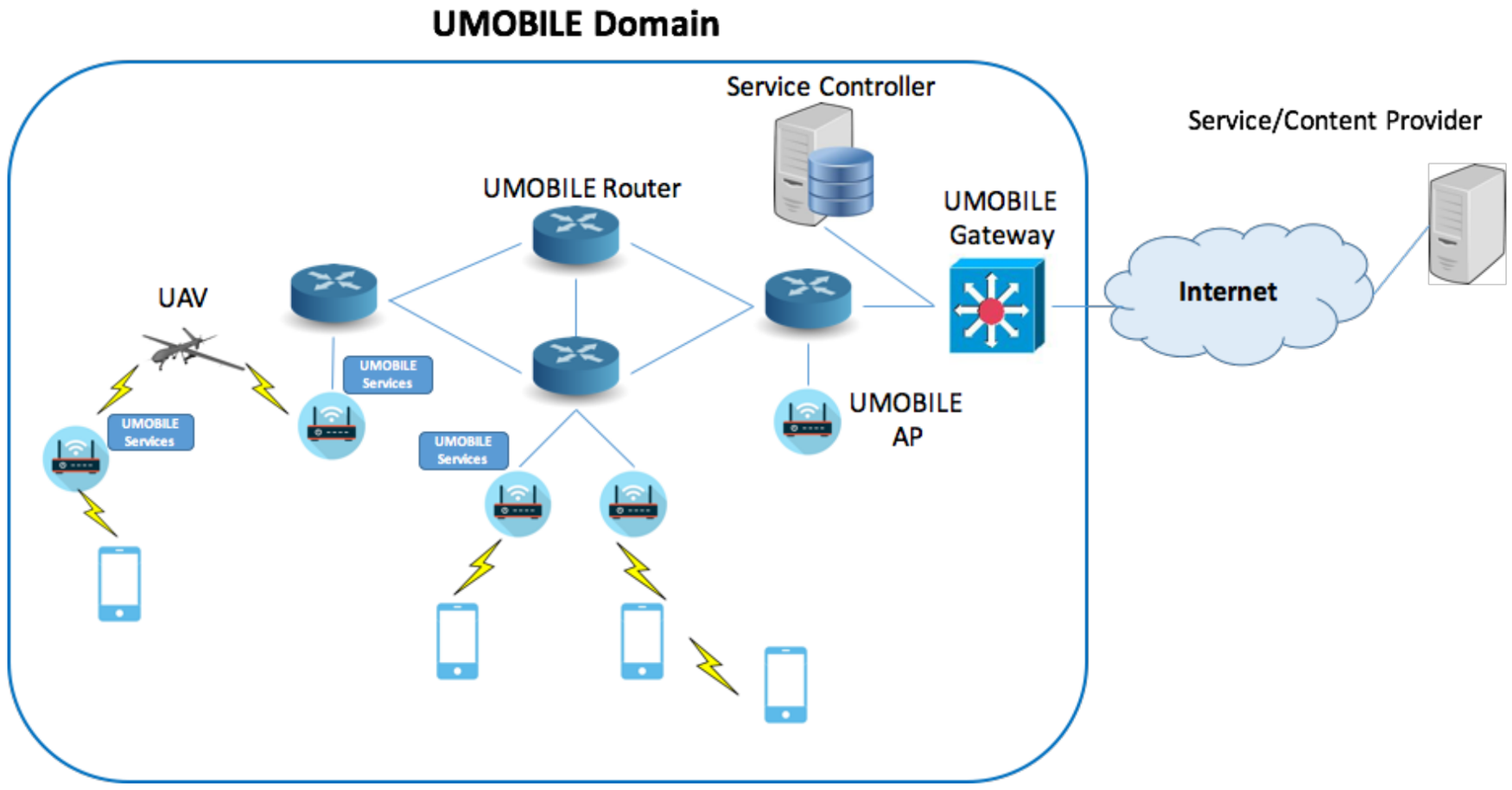

**Multi-layers QoS mechanisms**

- Development of application level QoS mechanisms
  - Manipulation of the application and its deployment: mainly service migration/replication.
  - Take advantage of ICN abstractions (for ex. in-network caching, data replication and multicast).

- Development of network level QoS mechanisms
  - Manipulation of network packets: mainly congestion control
  - Provide opportunistic communications through DTN tunnelling

# Application level QoS: Service Migration Issues






Common sense suggests that to reduce latency the service should be deployed close to the end user (edge computing).

**"Close"** can be interpreted as physical (geographical distance) and logical (link bandwidth) proximity.

## What are the research questions?

- Determine a good place to migrate/replicate the service so that latency is reduced.
- Redirect users' requests to the right replica so that latency is reduced.
- Optimise the cost of service migration: Storage, Migration traffic (migrating the service across the network –> can cause congestion)
- We have started with replica placement.

# Service Migration: High Level Design

**DECISION ENGINE**

- **Decide when and where to migrate/replicate the services**
  - **Improve QoS (e.g., access latency, availability)**
  - **Minimise the cost of migration/replication (e.g., storage, migration traffic)**
  - **Provide different classes of QoS (D4.4)**

**ICN-BASED DATA DISSEMINATION**

- **Name based routing**
  - **Decouple the location of producer and consumer**
  - **Multicast by name**
- **Service/Content Distribution (Migrate service to the edge)**
  - **Benefit from in-network caching of NDN**
  - **Push communication model**
- **Service/Network monitoring**
  - **Pull communication model**

**Service Execution**

- **Operating the lightweight services with service virtualisation**
  - **Understanding the scalability issues and performance**
  - **Identifying the critical constrains of the system for deploying services**

# Service Migration: Service Execution

**UMOBILE Access Point (SEG)**

## UMOBILE Innovation

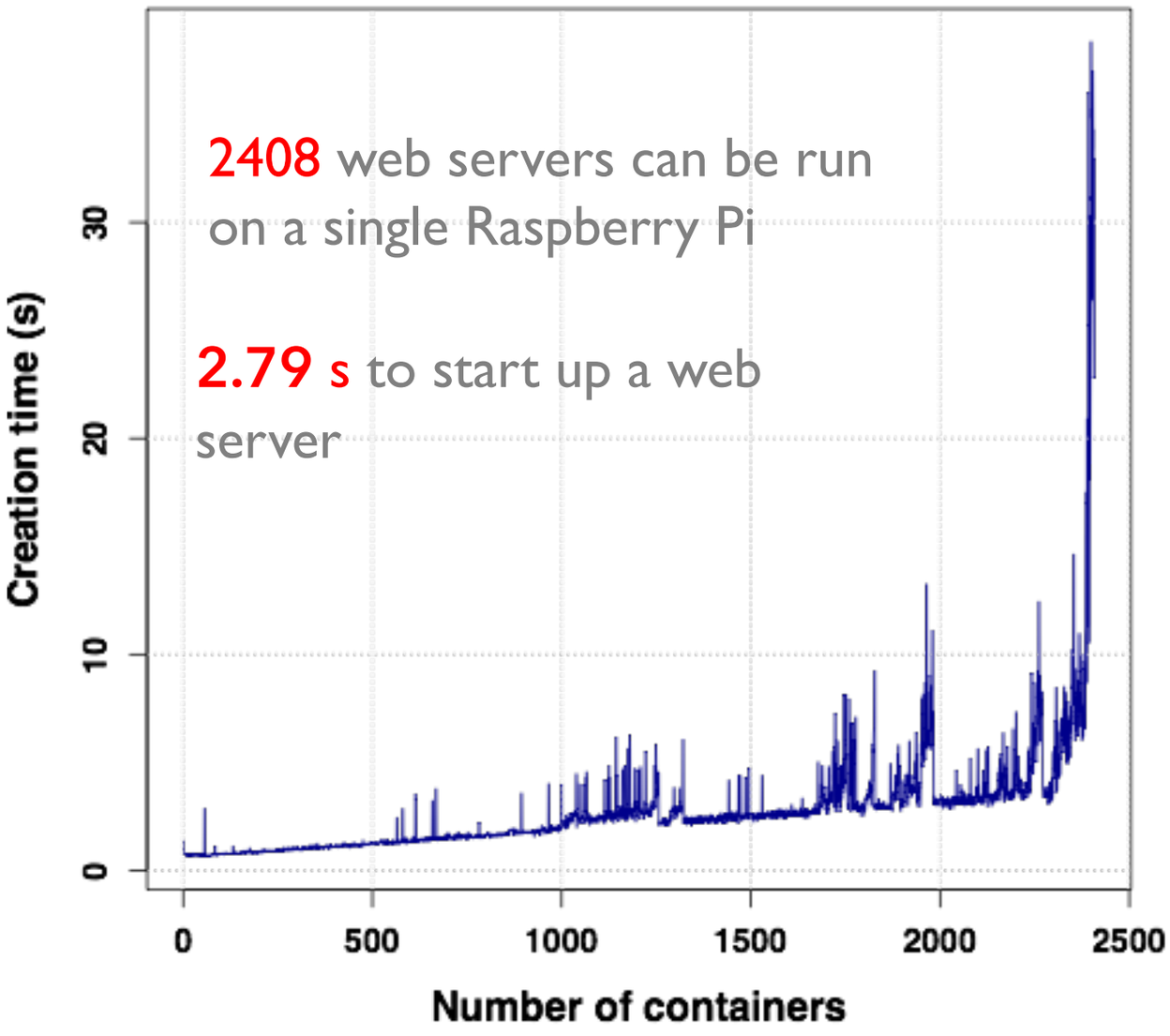
- **Service is executable (edge computing )**
- **Service/Content is cacheable (edge caching)**
- **Supporting service migration**
- **Supporting ICN-DTN**

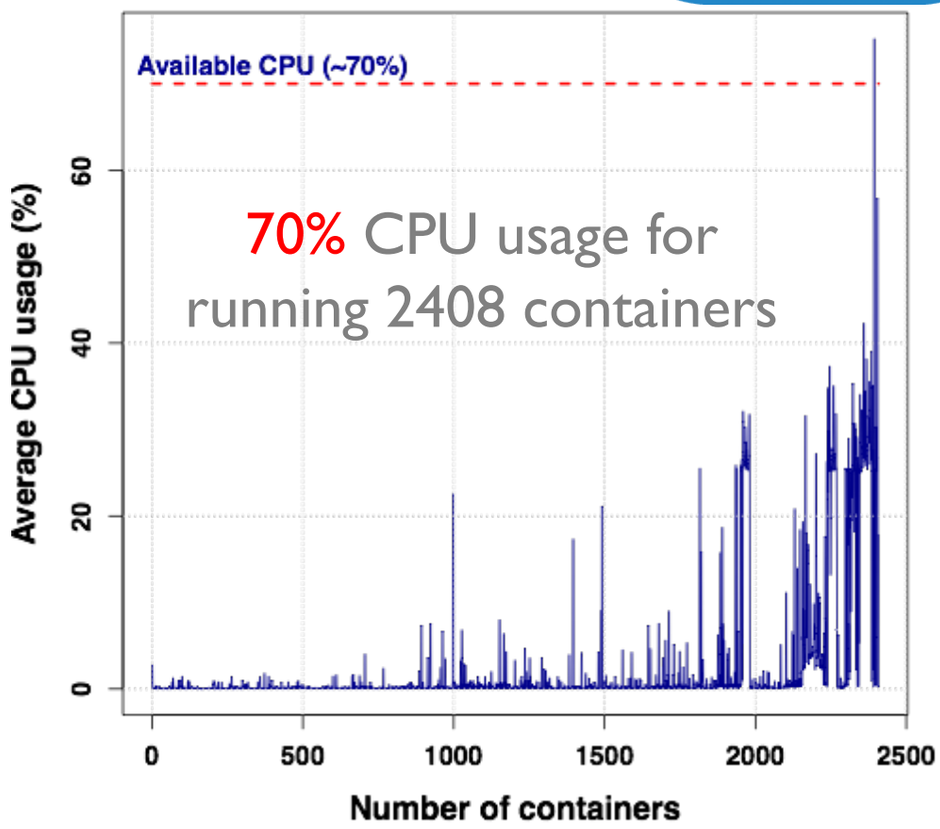
- **Benchmarking scalability[2]**
  - **How many containers can be supported by a specific raspberry Pi ?**
  - **How many user requests can be supported by a single container?**

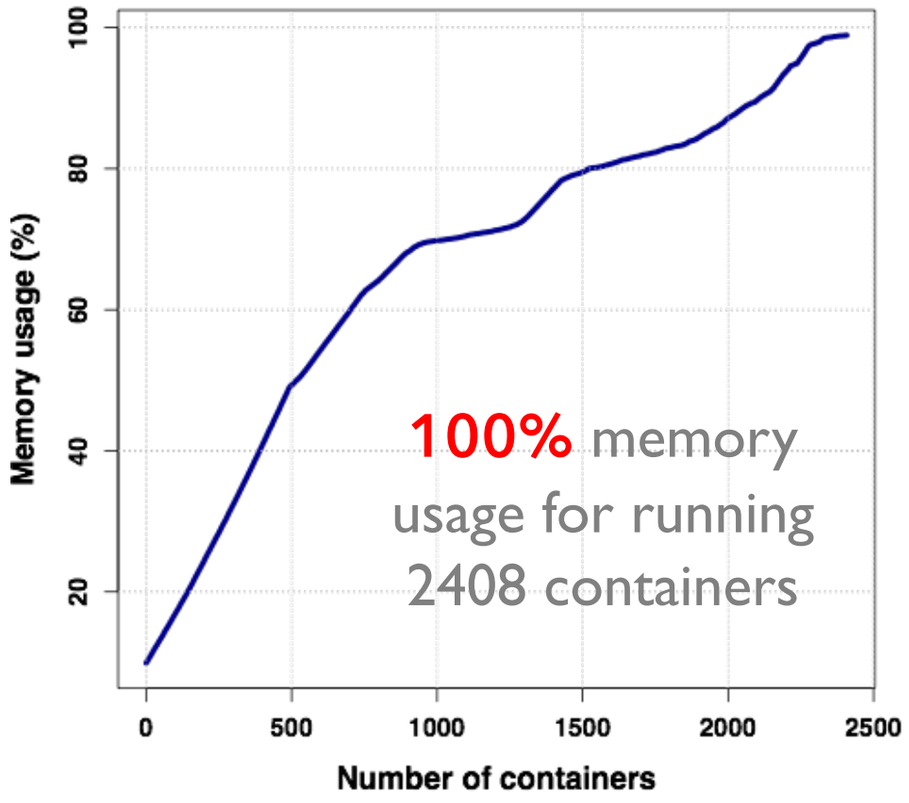
[2] A. Sathiaseelan, A .Lertsinsrubtavee, A. Jagan, P. Baskaran, J. Crowcroft, "Cloudrone: Micro Clouds in the Sky", ACM Mobisys Dronet, 2016.

# Scaling up the number of deployed containers within a PI

- Testing with simple web server image (html + a small jpg)
- Container size is about 90 KB



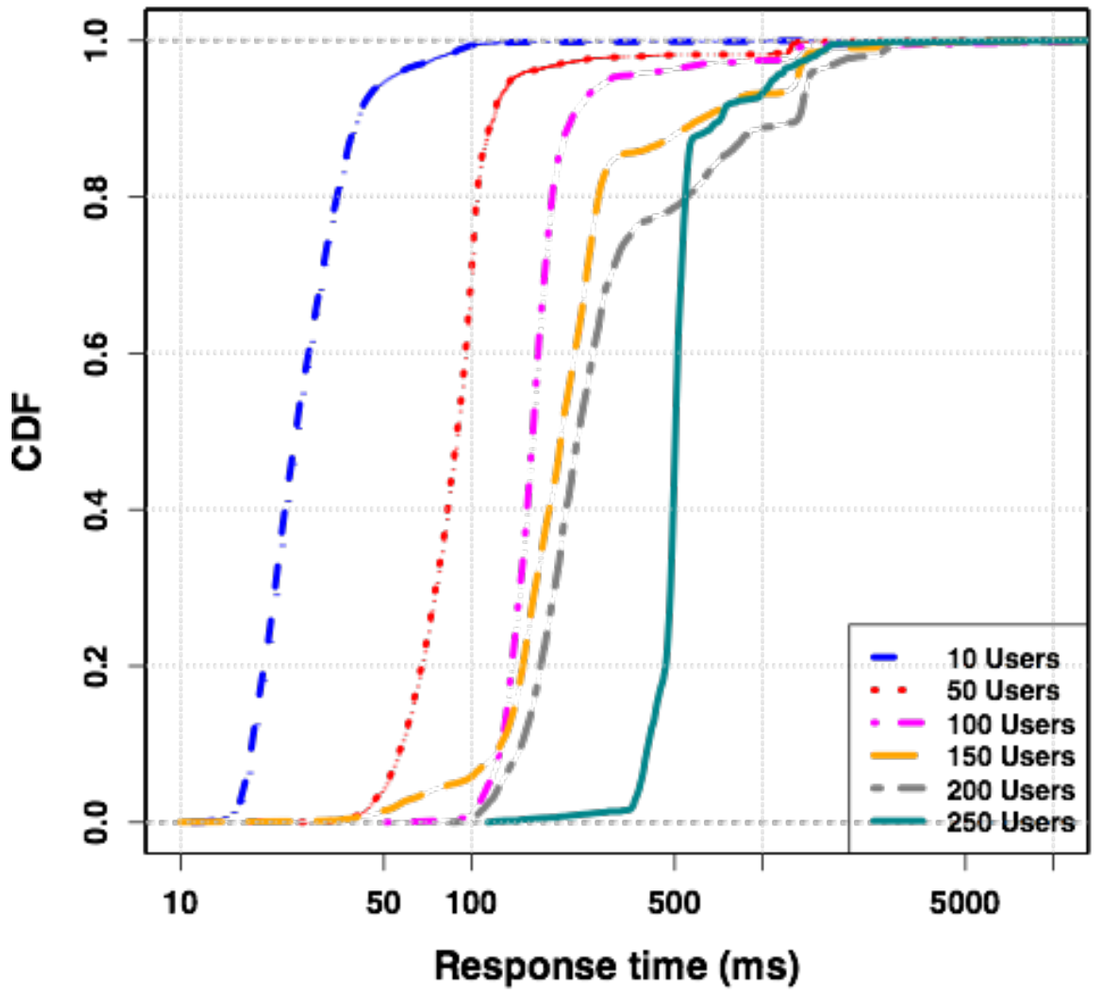



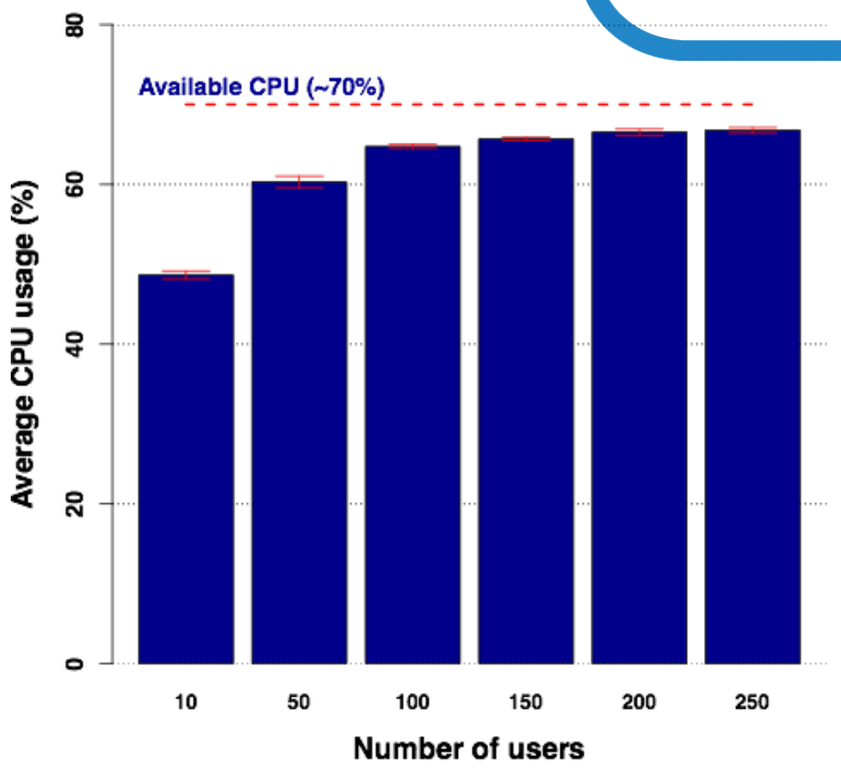




The initial memory usage before creating the first container was about 98 KB (a PI has 1GB RAM ).

# Scaling up the number of users accessing a single service

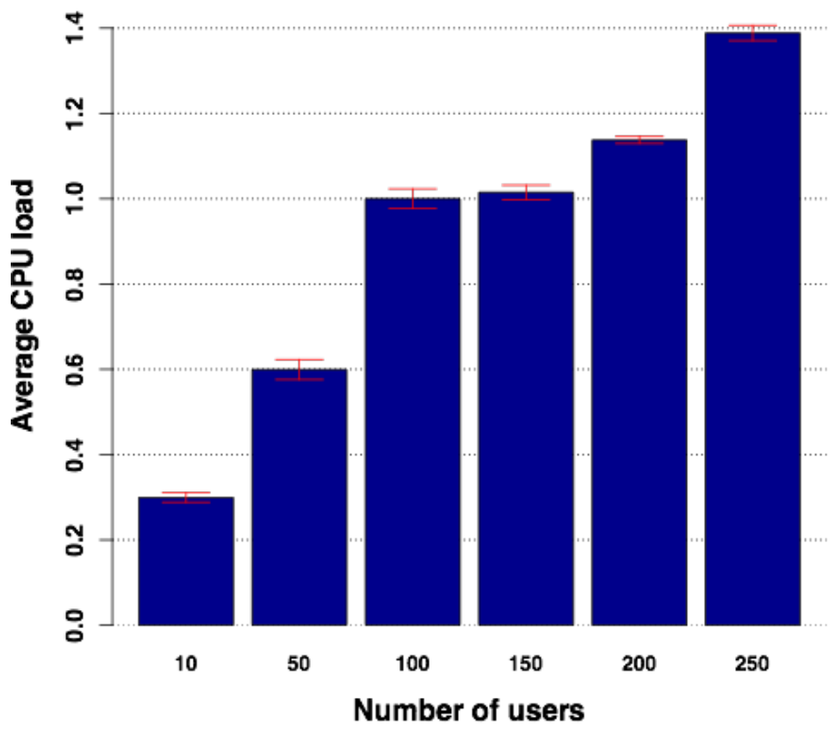
- Scaling the number of concurrent users from 10 to 250
- 10,000 transactions were set per experiment



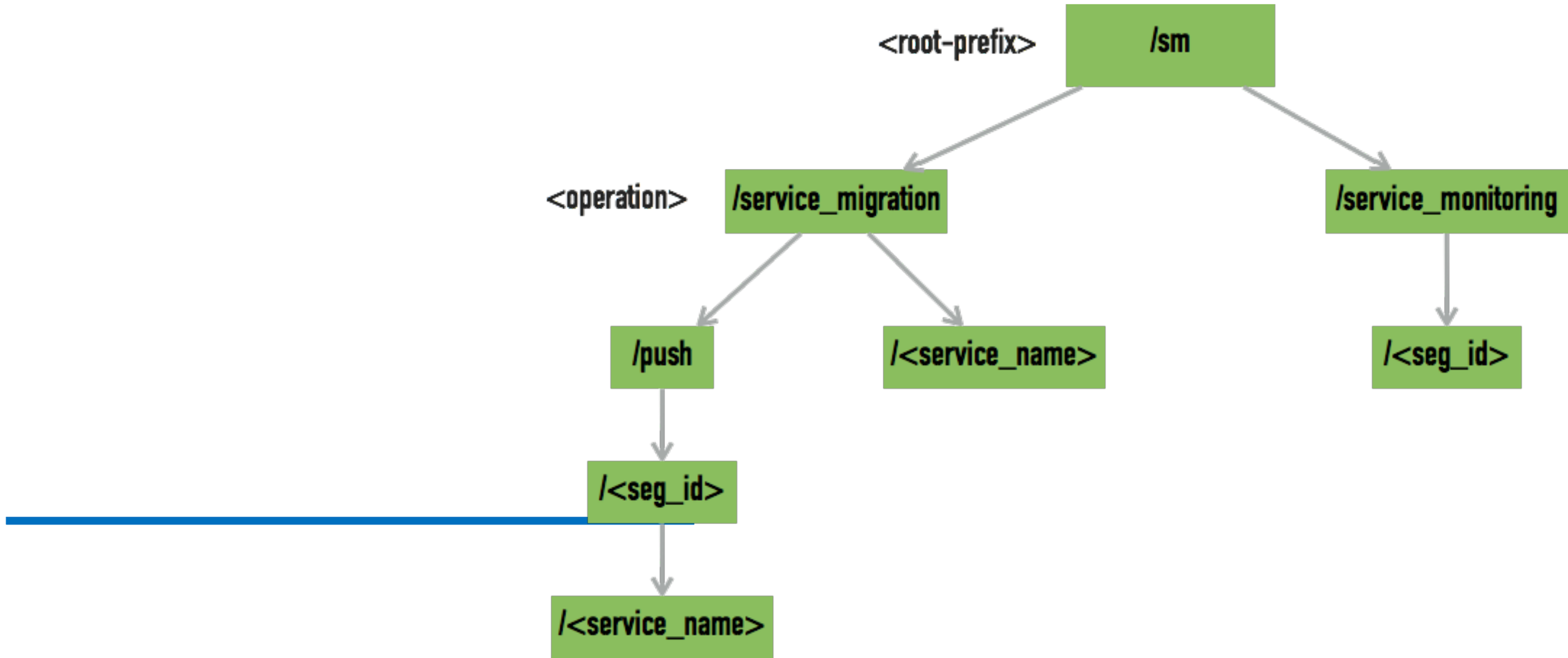

- High response time when number of users is large
- The amount of computational work that CPU needs to process (**CPU load**) is increased.

CPU load is increased up to **90%**



# Service Migration: ICN-based Data Dissemination

| Operation | Model | Nature | Producer | Consumer |
|---|---|---|---|---|
| **Monitoring** | Pull based | Many to One | All SEGs | Service Controller |
| **Migrating Services** | Push and Pull based | One to Many | Service Controller | SEGs |



# Service Migration Scenario Example

WEB

**Repository**

**GATEWAY**

**Service Controller**

WEB

**Service Provider**

- Upload service
- Specify QoS

- Monitor service/network usage
- Make a decision where to migrate the service

WEB

SEG_1

SEG_2

**User Device**

SEG_3

SEG_4

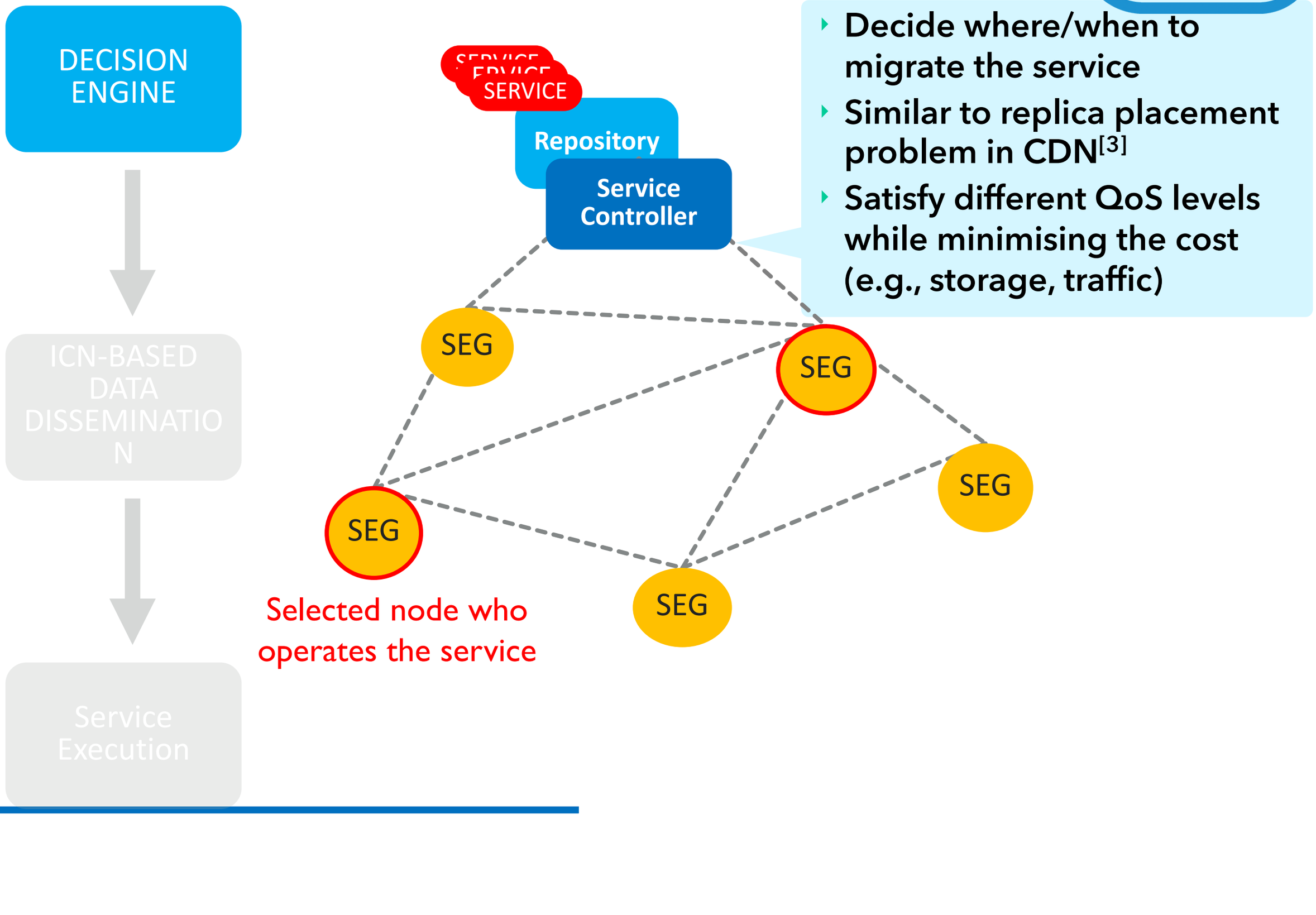
- Access the service through the nearest SEG with IP connection

NDN connection

IP connection

**SEG = Service Execution Gateway**

# Service Migration: Decision Engine



# Status - Month 18

**DECISION ENGINE**

- Identify and measure critical constraints of the system [Done]
  - These parameters include CPU load, Memory, number of users, storage (from service execution benchmarking)
- Identify the QoS requirements [On going]
- Develop heuristic algorithms for decision engine [On going]

**ICN-BASED DATA DISSEMINATION**

Implemented the service migration frame work [Done]
Network/Service monitoring using pull based communication [Done]
Service Virtualisation over NDN (Docker and NDN integration) [Done]
Multicast communication through named based routing [Done]
Optimising the traffic through in-network caching [On Going]
Redirect users' requests to the closet replica over NDN [On Going]

**Service Execution**

- Operating the lightweight services with service virtualisation [Done]
- Understanding the scalability issues and performance [Done]

# Demo: Service Migration Push



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# PerSense Mobile Light - Senception



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# UMOBILE

## Our Contributions/Demos

- Senception will use PerSense Light  in task 4.2 to perform an analysis on data contextualization and on network mining aspects relevant to UMOBILE
- **Phase I – 2016 UMOBILE demo I (April 2016)**
    - Framework derived from smart data capture, characterization of social routines based on Wi-Fi footprinting
    - Based on SQLite, server provided by Senception to the project
- **Phase II – 2016 UMOBILE demo (May 2017) – v2.0**
    - Sociability forecasting software  (Android)
    - User recommendations and prediction of conditions for social interaction to occur derived from shared interests, affinities, and wishes via the application of social indicators to forecast sociability in space and time
    - Usage context adapted to the UMOBILE architecture
    - For smartphones and desktop (UNIX)

# UMOBILE

## Which Requirements are we Meeting ?

- **PerSense Light v1.0 contributes to the following UMOBILE requirements**
  - R1: assists in understanding social trust circles; how they organize (contextual aspects) and their duration
  - R4: keeps all data local; relies on network mining and not on personal raw data capture
  - R10: helps in understanding the relation between location and social daily routines (roaming patterns and geographical regions)
  - R18: performs seamless sensing of user context
  - R20: provides feedback about networking dynamics, based on realistic social routines (roaming patterns)
  - R23: allows authorized people to track the routine of registered devices
  - R24: does not need an always on Internet access
  - R26: allows users to manage their trust circles
- **Sociability forecasting module in PerSense Light contributes to the following UMOBILE requirements**
  - R15, R16: assits in inferring user interests by analysing local usage
  - R18: performs seamless sensing of user context
  - R24: does not need an always on Internet access
  - R27: assists in matching familiar strangers' interests and assists in facilitating meetings

# UMOBILE

## Methodology/Roadmap

- **Contextual Inference based on a specific product by Senception – April 2016 onwards**
  - Light binary (apk) provided to the UMOBILE consortium
  - **Purpose:** scientific studies and traces; provide a concrete contextual inference (network mining)
  - Captures wireless foot printing aspects (distances, APs; visits type and duration
  - Data dumped to a specific server – server provided by Senception
    - First, integral database per user; 2017: global database for all users
    - Prepared to allow studies with any partner (binary)
    - ***Can be extended upon request, to capture parameters relevant to partner***
- **Benefits for UMOBILE**
  - Adequate contextualization aspects: goal of task 4.2
  - Traces
    - UMOBILE shall profit from a database provided by Senception
    - Traces sent to Crawdad once they are stable
  - Dissemination
    - Senception shall also work with interested partners to develop studies worldwide

# UMOBILE

## Demo, PerSense Light

- **Apk running on Android devices**
  - Igor will ask several people to install the apk before the meeting

- **Contextual Inference based on a specific product by Senception – April 2016 onwards**
  - Light binary (apk) provided to the UMOBILE consortium
  - **Purpose:** scientific studies and traces; provide a concrete contextual inference (network mining)
  - Captures wireless foot printing aspects (distances, APs; visits type and duration
  - Data dumped to a specific database (SQLite) – server provided by Senception
  - Prepared to allow studies with any partner (binary)
  - ***Can be extended upon request, to capture parameters relevant to partner***
- **Benefits for UMOBILE**
  - Adequate contextualization aspects: goal of task 4.2
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# UMOBILE

## PerSense Light – Parameters tracked

- **Roaming data is collected in real-time**
  - Stored per day, week , 1 month – SQLite
  - Can be dumped to a server (night)
  - Collects visited APs and affinity networks
    - Distinguishes between connected APs and non-connected Aps; devices in contact and jut in the vicinity
- **Database Format (SQLite)**
  - ***Roaming tables***
    - 16 tables, 1 for each day of the week; 1 for each week 1 to 5; 1 for the month
      - Table entry tupple for each AP: <Id, bssid, dayoftheweek, state, ssid, attractiveness*, lastgatewayIP*, dateTime, lat, long>
    - ***Visits table***
      - Connected APs
      - Entry tuple: <Id, ssid, bssid, timeon, timeout, dayoftheweek, hour>

# UMOBILE

## PerSense Light – How does it work

- **Database Format (SQLite)**
  - ***Affinity Network tables***
    - Captured via Wi-Fi Direct
    - 16 tables, 1 for each day of the week; 1 for each week 1 to 5; 1 for the month
      - Table entry tupple for each device in the vicinity: <Id, bssid, dayoftheweek, state, ssid, attractiveness*, lastgatewayIP*, dateTime, lat, long>
- **Data can be backed up to a server provided by Senception**
- **Tutorial on how to use the tool to be provided by Senception upon request to partners, after the plenary**
- **Extensions are feasible – new binary can be provided by Senception, upon agreement with partner/consortium**
- **Senception wants to develop studies (papers) with partners**
  - Multiple countries, different demographics
  - We commit to analyze the collected data

*** Fields not in use in this version.**

# UMOBILE

## Demo, PerSense Light

**DEMO**

# Naming: the NREP concept


Senception Lda | rute.sofia@senception.com

# Why NREP

# Key Aspects

| Name-prefix | Priority | Time-to-live | Space | Authorization | Recipient | Notes |
|---|---|---|---|---|---|---|
| SOS | High | Short | Closeby | All | First responders | To use to ask for help |
| Government | High | Indefinite | All | Officials | All | To inform all of food-shelter,danger |
| First-Responders | High | Indefinite | Depends | First-Responders | All | To inform all of rescue-teams arrival |
| Warning | Medium | Indefinite | All | All | First Responders | FR verify and publish to all |
| Police | High | Depends | Depends | Police | Police members | To chat among themselves |
| safe | Medium | Short | All | All | Public/Family | To inform others that they are safe |
| chat | Low | Low | All | All | Public | To chat among each other |

# Roadmap

- **Phase I – Task deadline (January 2017)**
  - Framework derived from previous work on name-based replication priorities for emergency services based on social interaction and prioritization

- **Phase II – UMOBILE demo (July 2017??)**
  - Implementation of the NREP solution integrated into the UMOBILE architecture over smartphone solutions (i.e. Android).
  - Plan and development of a demo to show the benefits of NREP in the project review

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# UMOBILE

## WP4, Deliverables Status

| Deliverable | Task | Status (2016.04, month 14) | Due on |
|---|---|---|---|
| **D4.1 : Flowlet Congestion Control – Initial Report**<br>*This document includes the initial specification of the rate-regulation scheme for flowlets that allows ISPs to have full control of the traffic within their network.* | 4.1 | -Moved to Month 18<br>-- UCAM needs to provide report template<br>-Partners need to commit to specific sections | -Month 18: July 2016 |
| **D4.2 : Flowlet Congestion Control – Final Report**<br>*This document defines the final specification of the rate-regulation scheme for flowlets that allows ISPs to have full control of the traffic within their network.* | 4.1 | - Depends on D4.1 | - Month 24 (Jan 2017) |
| **D4.3 : Name-based Replication Priorities**<br>This document describes the mobile name-based replication system | 4.3 | Not started | - Month 24 (Jan 2017) |
| **D4.4 : Set of QoS interfaces and algorithms**<br>*This report describes the different level of services provided by UMOBILE platform* | 4.1 | Not started | - Month 28 (May 2017) |
| **D4.5 : Report on data collection and inference models**<br>*This deliverable includes all processes developed throughout UMOBILE project that involve data collection, context understanding and data dissemination, depending on the requirements of each scenario as well as the defined priorities.* | 4.2 | Not started | |

# UMOBILE

## WP4 Milestones, Status

| Goal | Status (2016.04, month 14) | Due on |
|---|---|---|
| MS7: QoS interfaces and mechanisms for data handling have been integrated within UMOBILE platform | No feedback | Month 30 |
| MS8: Flowlet Congestion Control developed | No feedback | M30 |