User Presence Detection Based on Tracking Network Activity in SmartRoom

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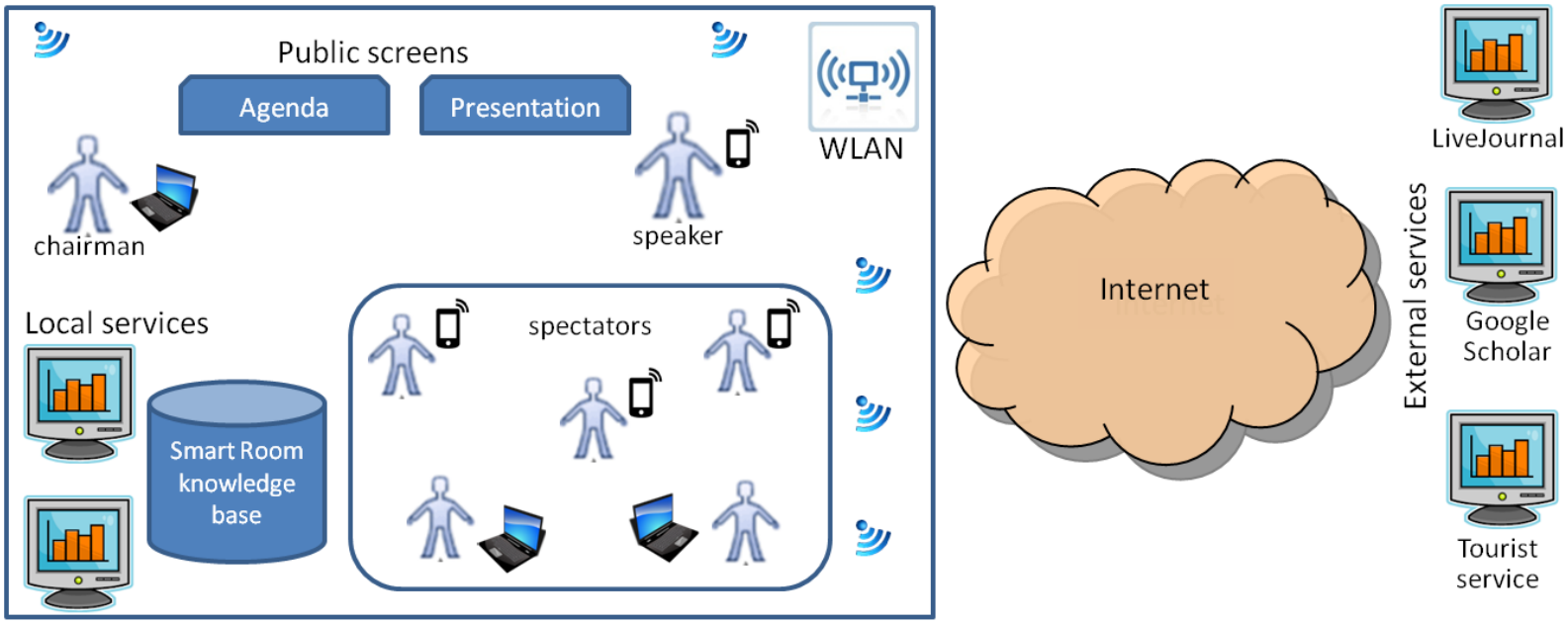
SmartRoom: Assistance for Collaborative Work

- Many services (composition, personalization)
- Participation of many users (user can be indoor and outdoor)
- Participants come with own devices and use personal clients
- Based on the Smart-M3 platform



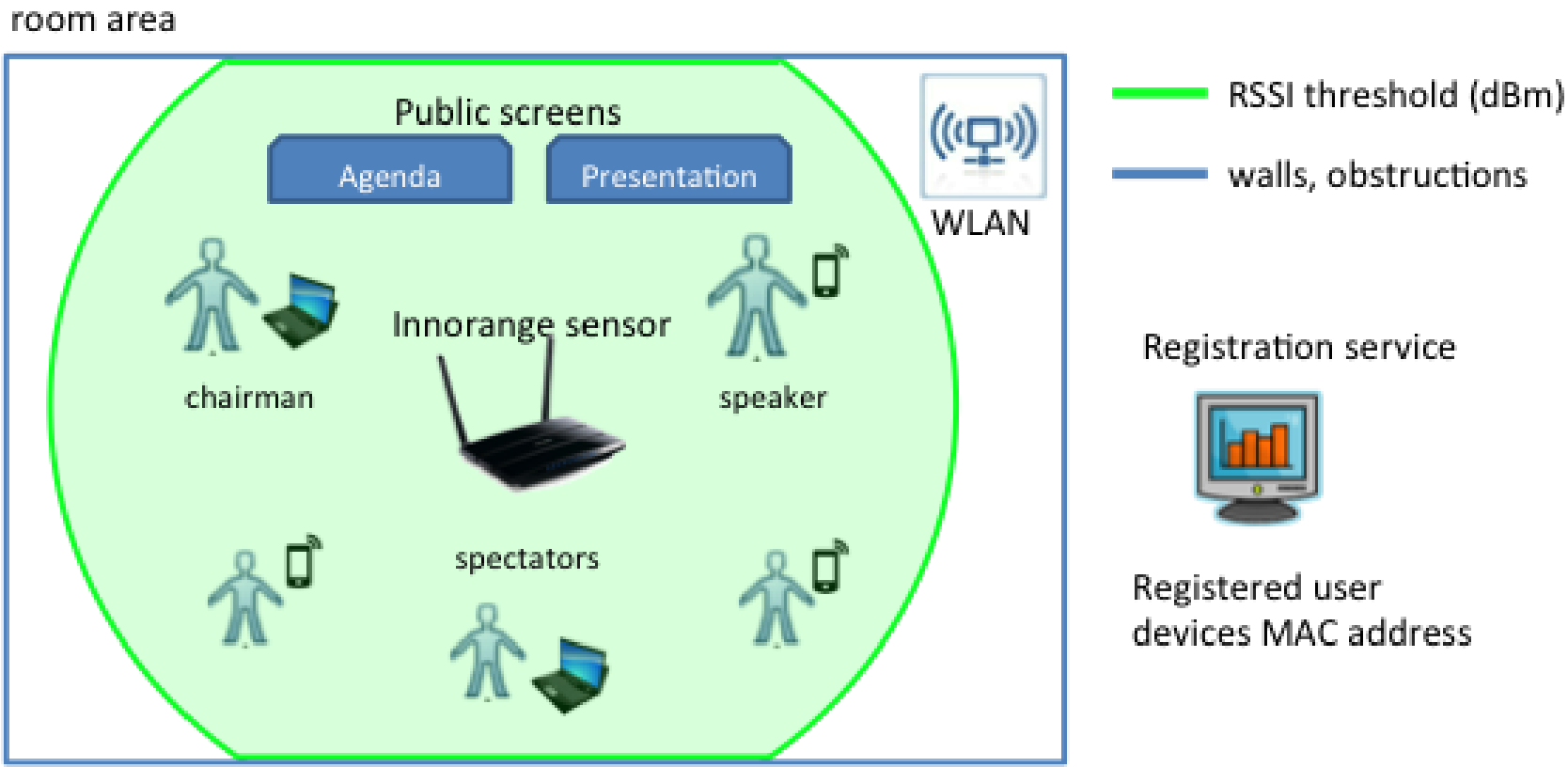
Presence Detection: Scenarios for SmartRoom

- SmartRoom services can be extended by utilization of runtime information on user presence in the room: physical and virtual
- This information is associated with network activity
- Each scenarios group supports a set of services:

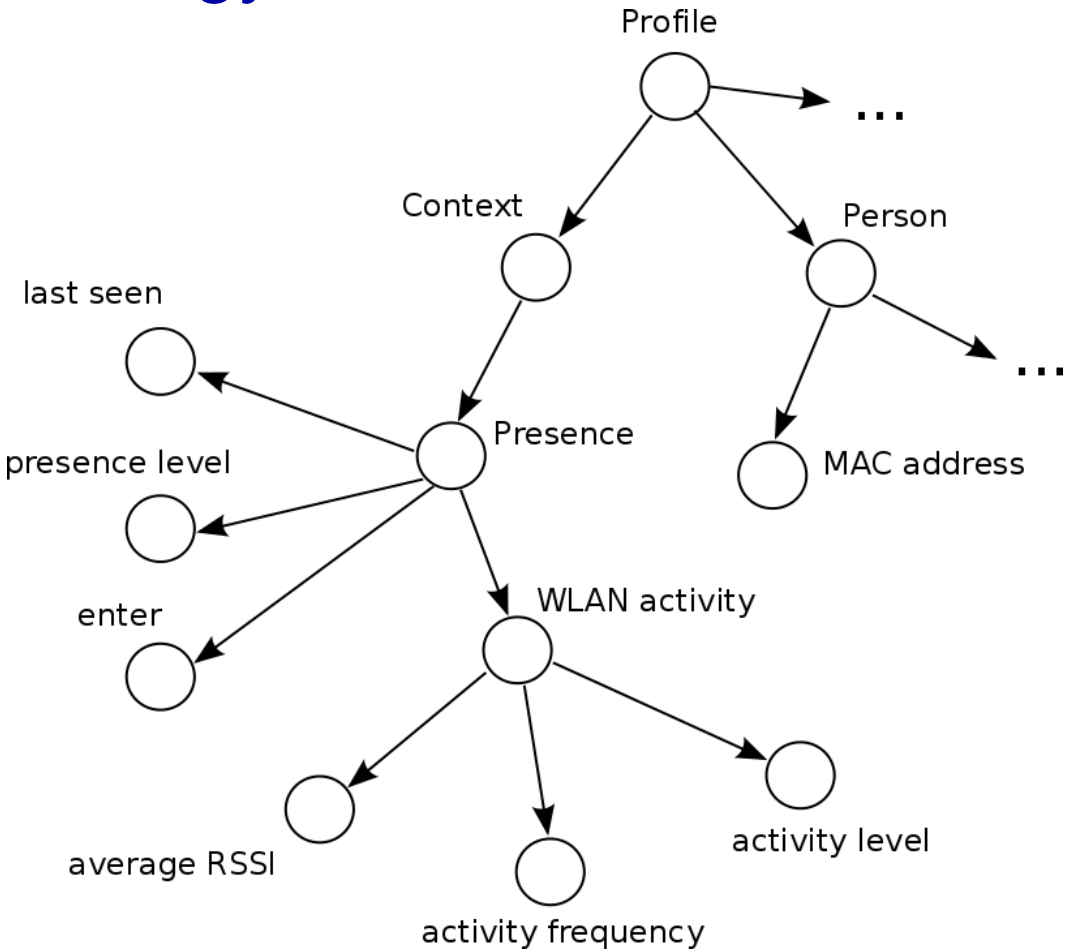
Scenarios group	**Description**	**Examples of services**
S_1 (before)	user arrival to the room before starting the main activity	– personalized welcome service – runtime initialization service
S_2 (during)	user joins and leaves during the main activity	– runtime status for agenda service – planning speeches service
S_3 (after)	activity statistics	– activity analysis service

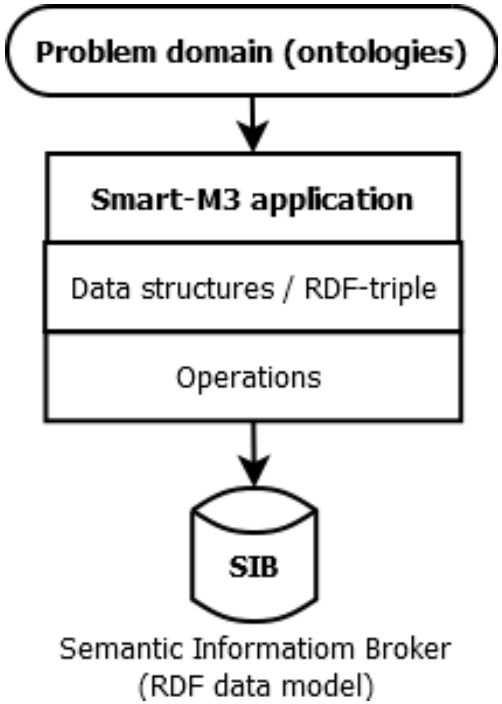
Presence Detection: Technology

- End-users have personal computers and mobile devices
- Radio Detection using Received Signal Strength Indication
- Innorange Footfall Technology
- Correspondence of users and MAC – registration service



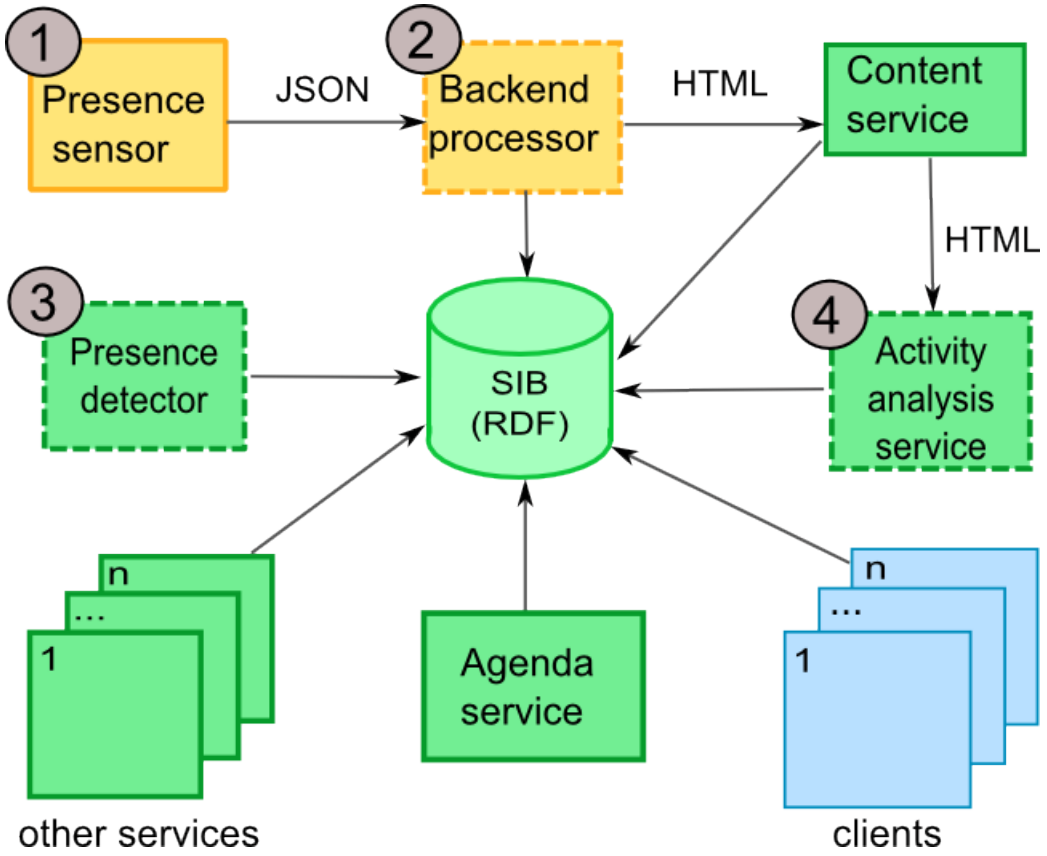
Ontology of User Presence





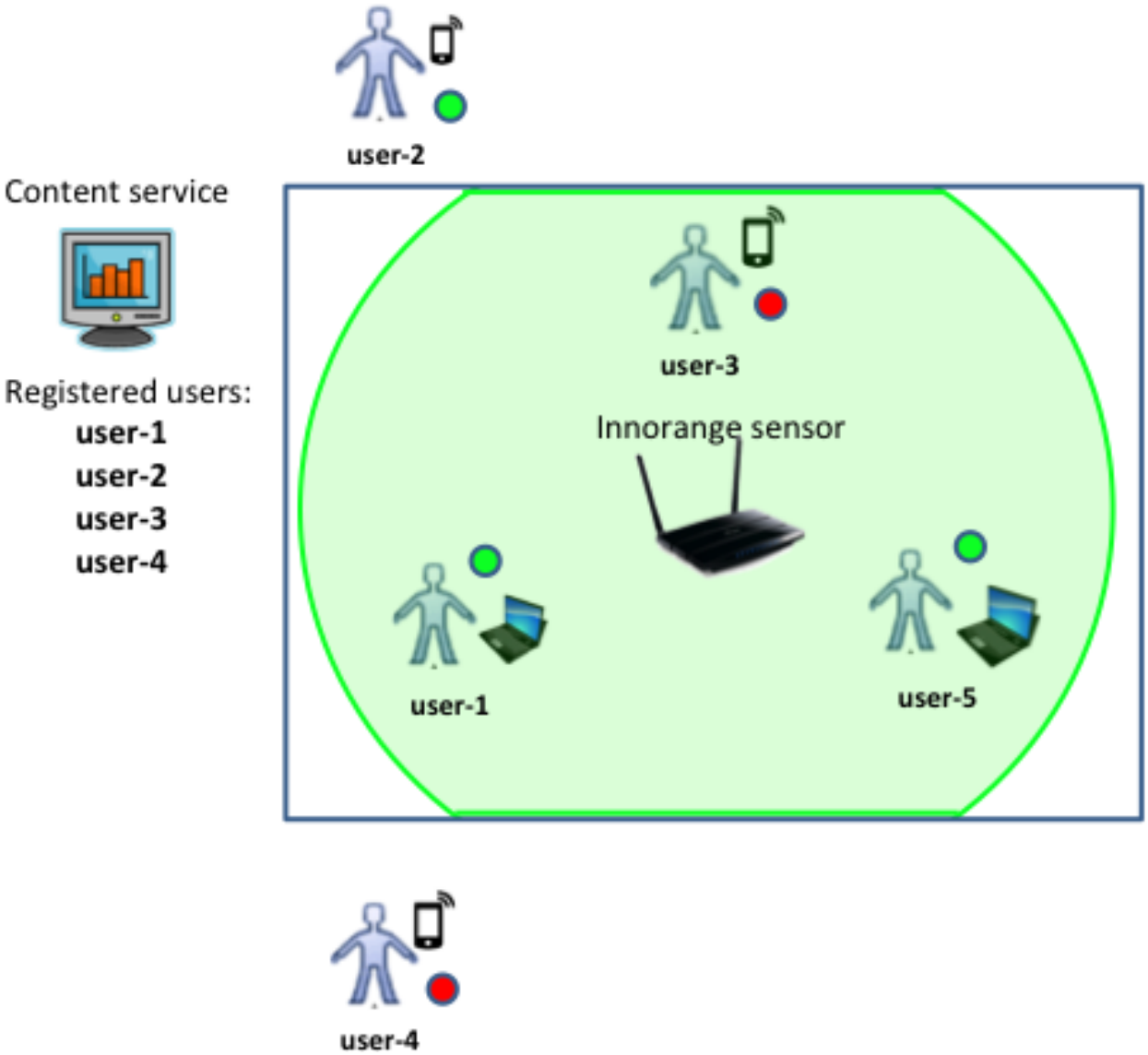
- Ontology of user presence is part of the SmartRoom ontology
- User presence is based on the context of the user profile
- All relationships here are of type “has”

Architecture of Smart-M3 based Integration



1. The presence sensor sends its measurements: MAC, RSSI and timestamp
2. Backend processor is HTTP endpoint to processing presence data from sensor
3. Presence detector KP detects presence information change
4. Activity analysis service processes of accumulated data from content service

User Presence: Device Detection + Other Context



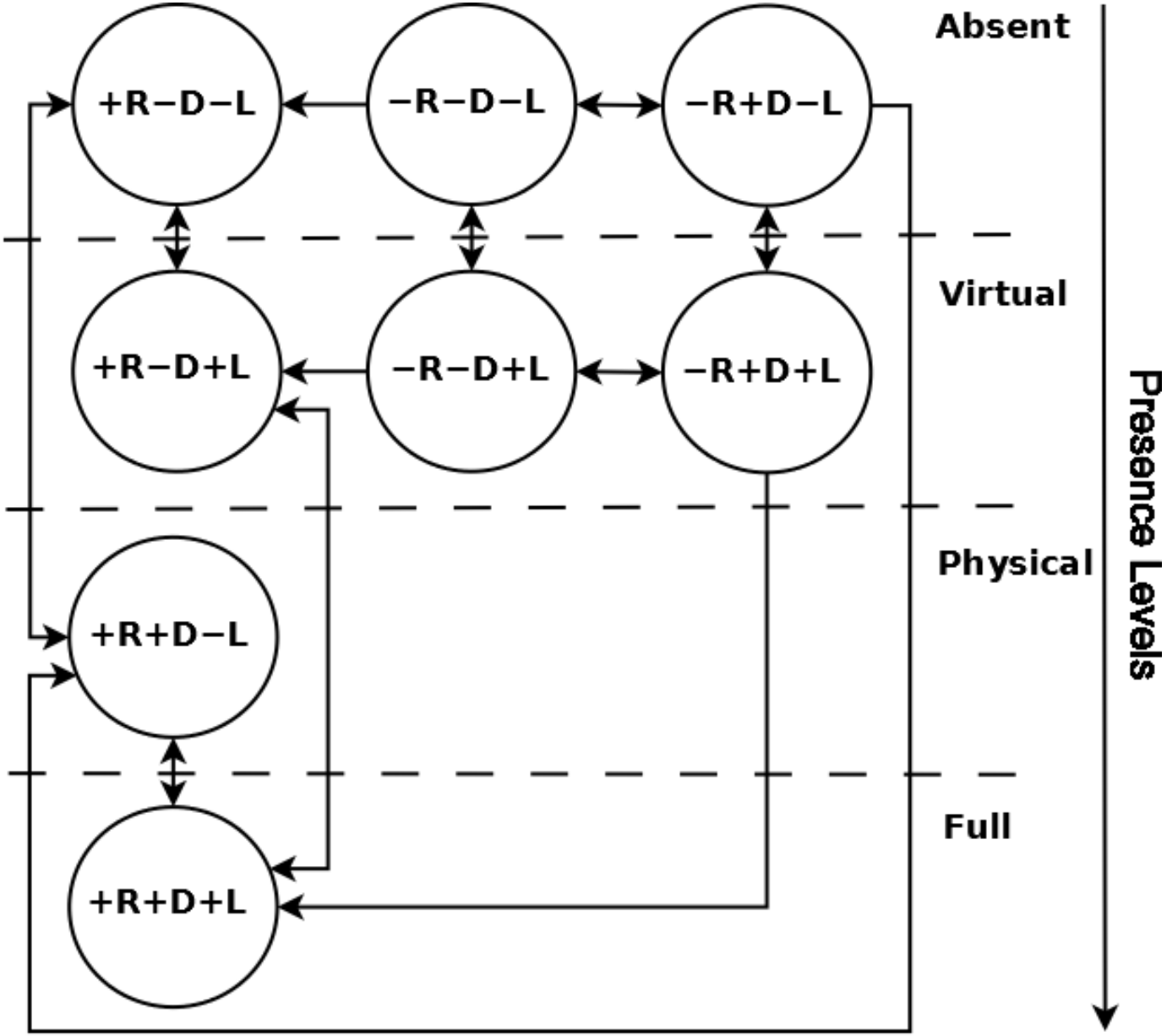
R: the user is registered in the system by content service

D: the presence sensor is detected user's device

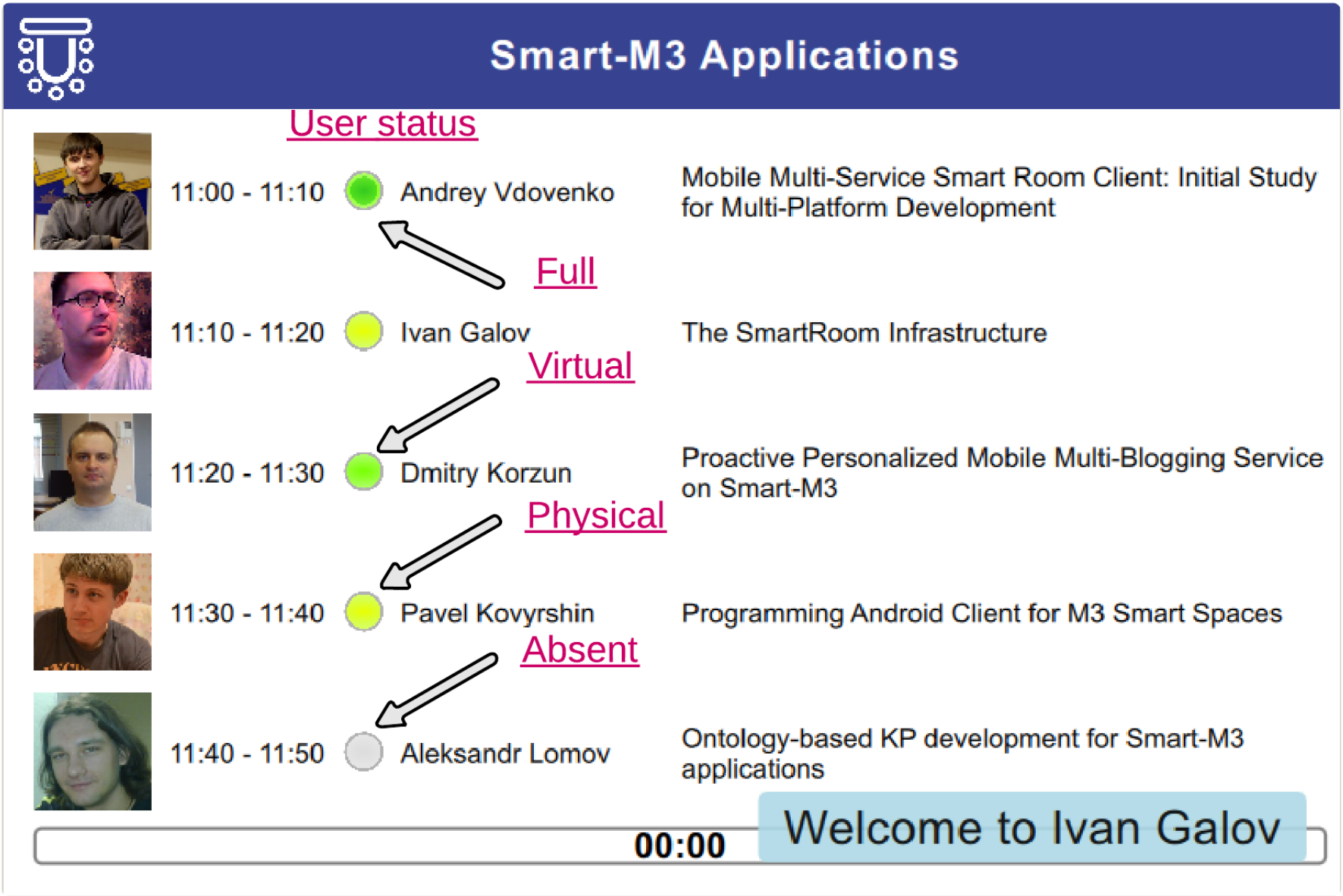
L: the user accessed the system using client

$$\text{user-1} \leftrightarrow +\text{R} +\text{D} +\text{L}$$
$$\text{user-2} \leftrightarrow +\text{R} -\text{D} +\text{L}$$
$$\text{user-3} \leftrightarrow +\text{R} +\text{D} -\text{L}$$
$$\text{user-4} \leftrightarrow +\text{R} -\text{D} -\text{L}$$
$$\text{user-5} \leftrightarrow -\text{R} +\text{D} +\text{L}$$

Model: User Presence State and Transitions



Visualization: Agenda-service of SmartRoom



Evaluation: Performance of State Transitions

Use case	S_1: **User arrival to the room**	S_2: **User joins and leaves during the main activity**
User arrival is detected before starting main activity	$+\mathrm{R}\,-\mathrm{D}\,-\mathrm{L} \;\rightarrow\; +\mathrm{R}\,+\mathrm{D}\,-\mathrm{L}$	–
User is detected after the first arrival	–	$+\mathrm{R}\,-\mathrm{D}\,+\mathrm{L} \;\leftrightarrow\; +\mathrm{R}\,+\mathrm{D}\,+\mathrm{L}$ $+\mathrm{R}\,-\mathrm{D}\,-\mathrm{L} \;\leftrightarrow\; +\mathrm{R}\,+\mathrm{D}\,-\mathrm{L}$

- S_1 and S_2 are based on detecting the transitions between states
- Evaluate the time required to detect transitions of S_1 and S_2
- Scenario S_3 aggregates history of presence detection

Evaluation: Conducted Experiments

Scenario S_1 (steps):

1. The presence sensor determines close device and sends the device presence data
2. The backend processor publishes presence data in ontological form
3. The presence detector updates the properties and publishes the presence level property
4. Any service that uses information on user presence subscribes to updates of the presence level property

Steps 1–4 take **Detection time**

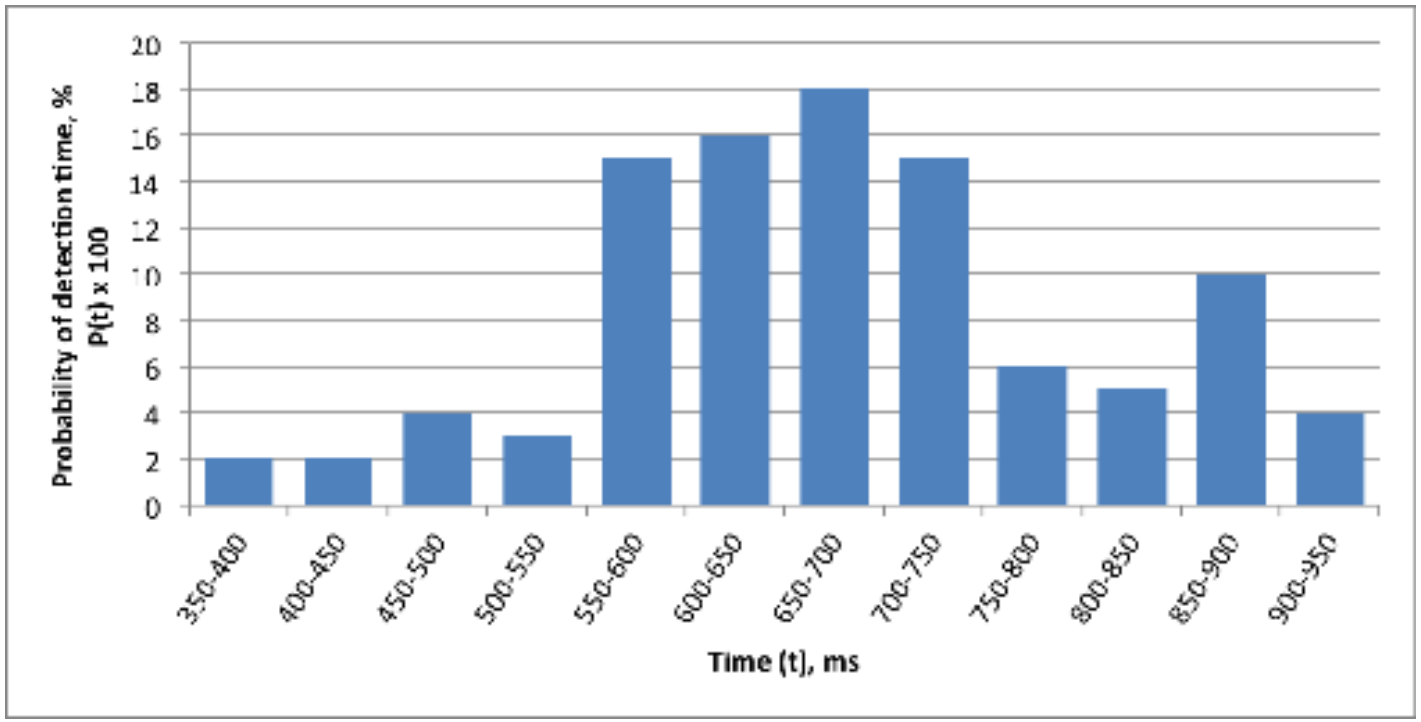
Scenario S_2:

1. **Leave threshold**
2. Re-joining the main activity (similarly as in S_1)

Scenario S_3:

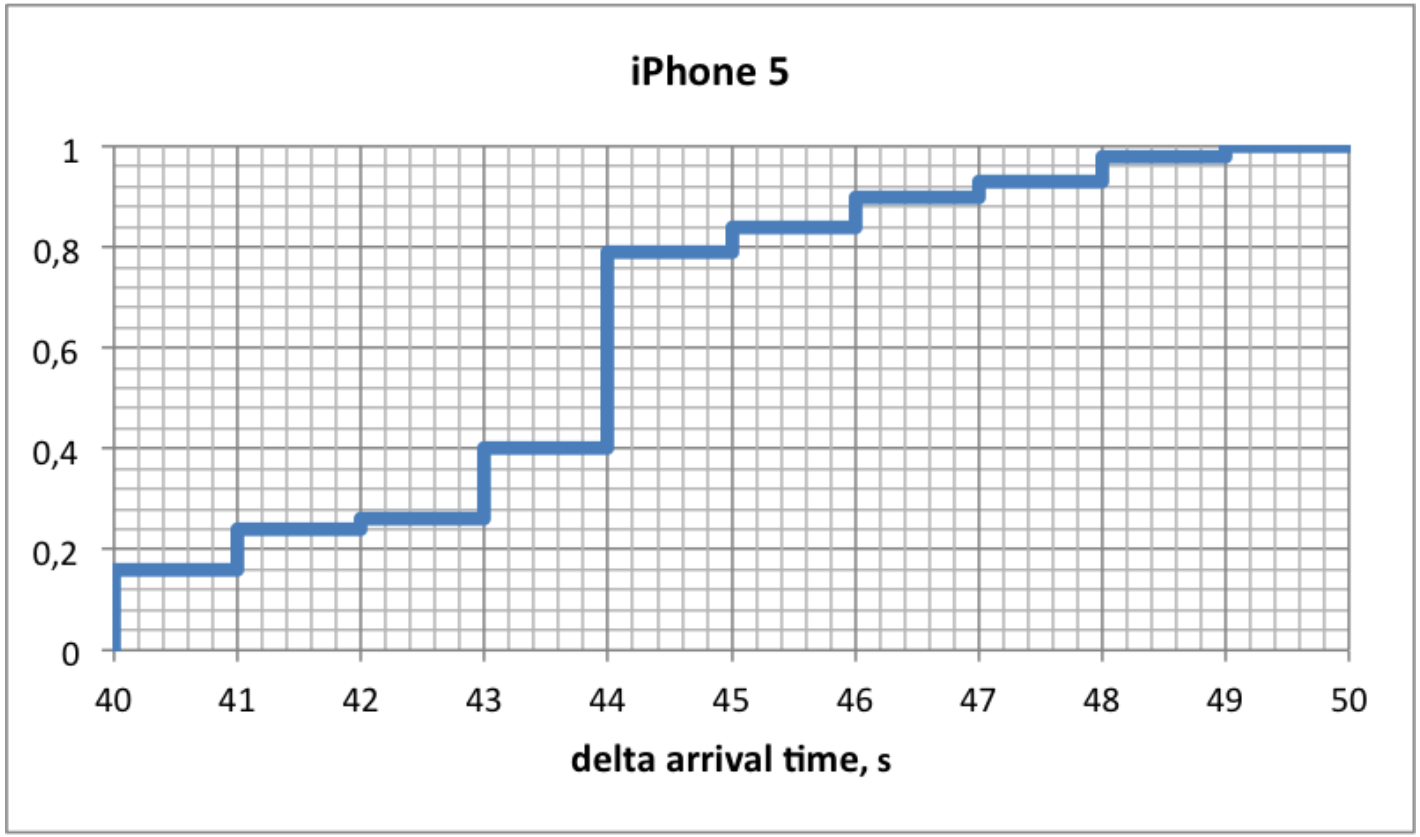
1. **Memory** occupied by the statistics files on the content service
2. **Processing time** activity analysis service of the network activity metrics

Evaluation: Detection Time in S_1



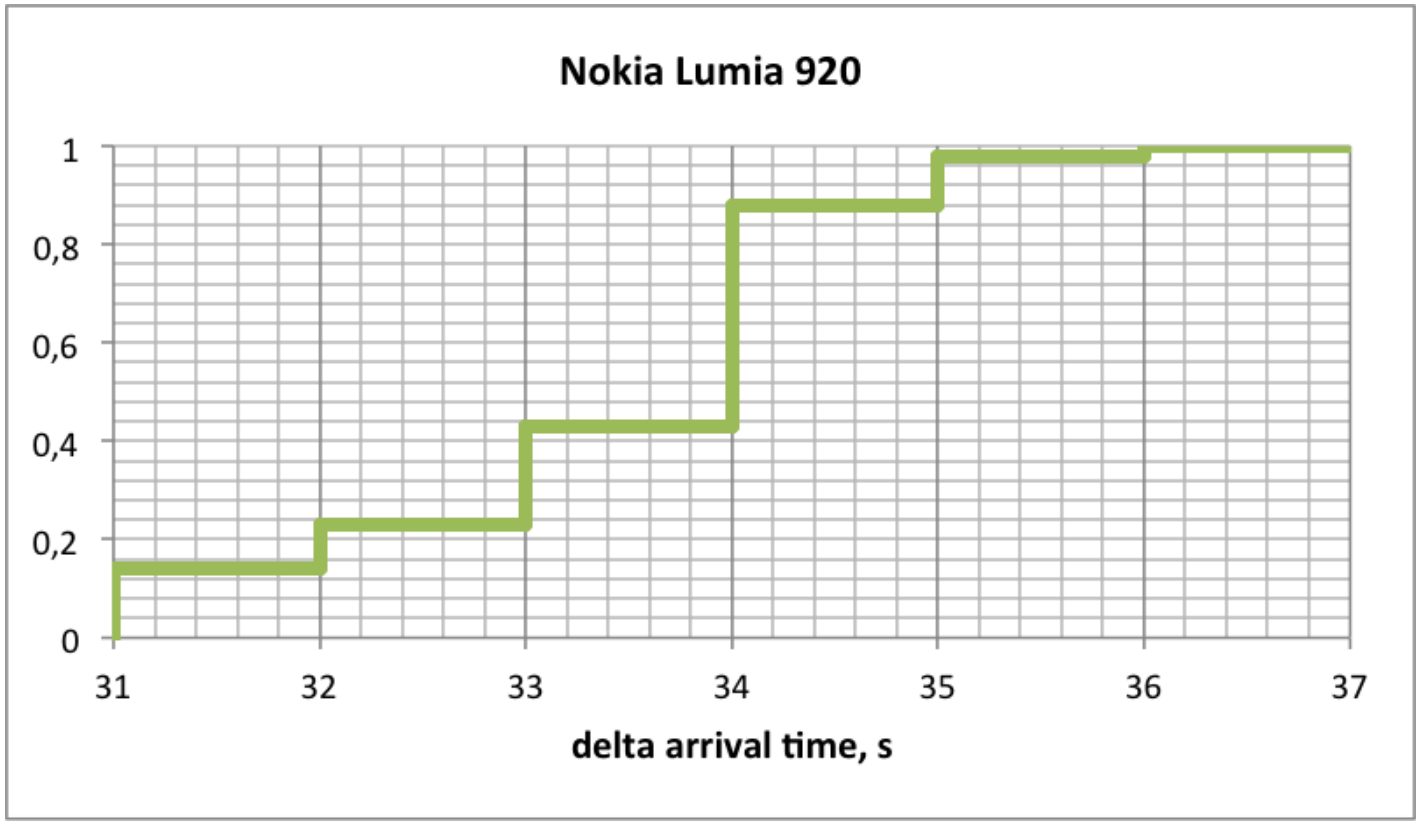
- Sample size is **100**
- Average detection time is **677 ms**
- Detection time does not depend on the number of devices

Evaluation: Leave Threshold in S_2 (1/3)



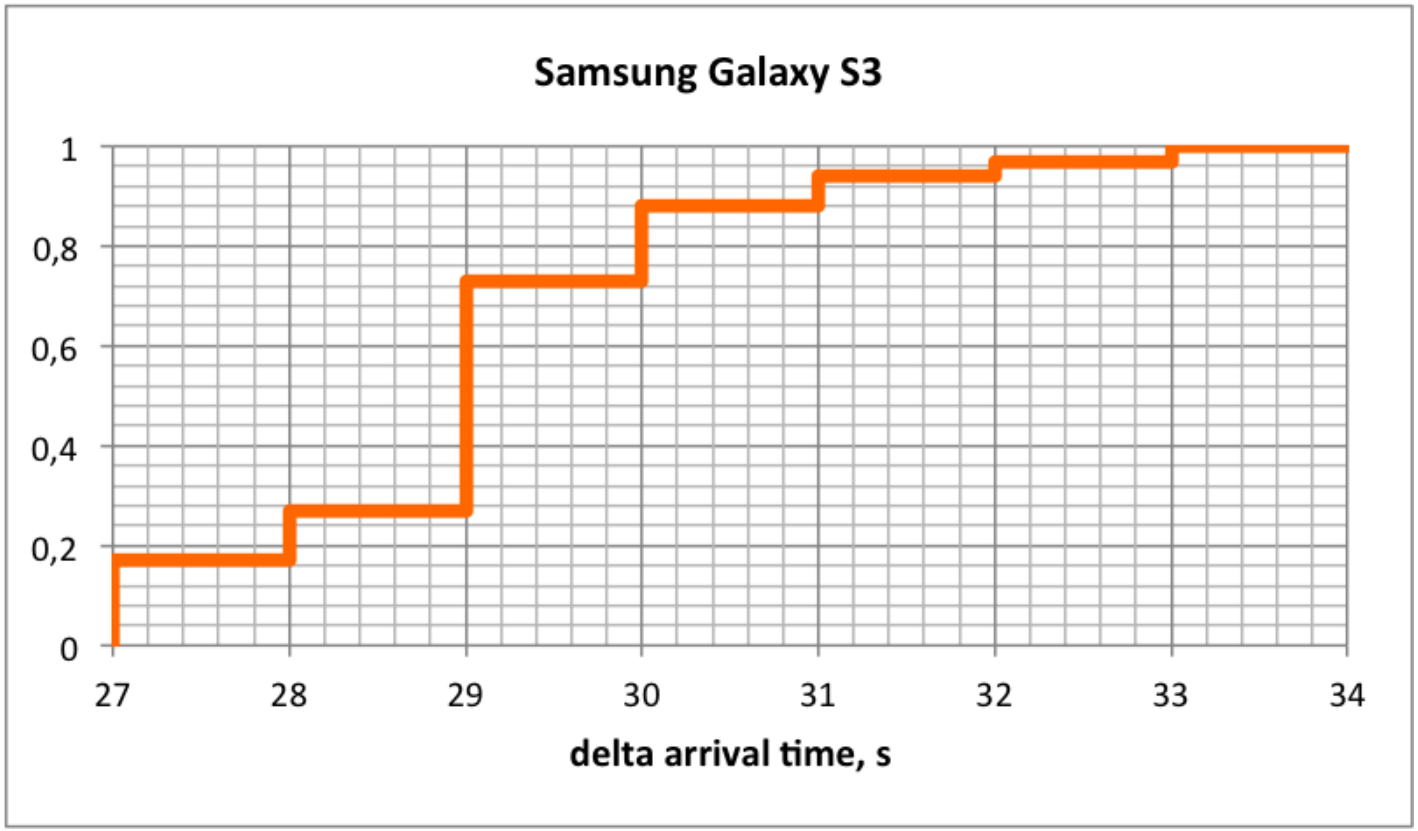
- For the **iPhone 5** device the distribution delta arrival time of probe request frames was in the range [**40**, **50**]
- The values of high probability are **45 s**

Evaluation: Leave Threshold in S_2 (2/3)



- For the **Lumia 920** device the distribution delta arrival time of probe request frames was in the range [**31**, **37**]
- The values of high probability are **35 s**

Evaluation: Leave Threshold in S_2 (3/3)



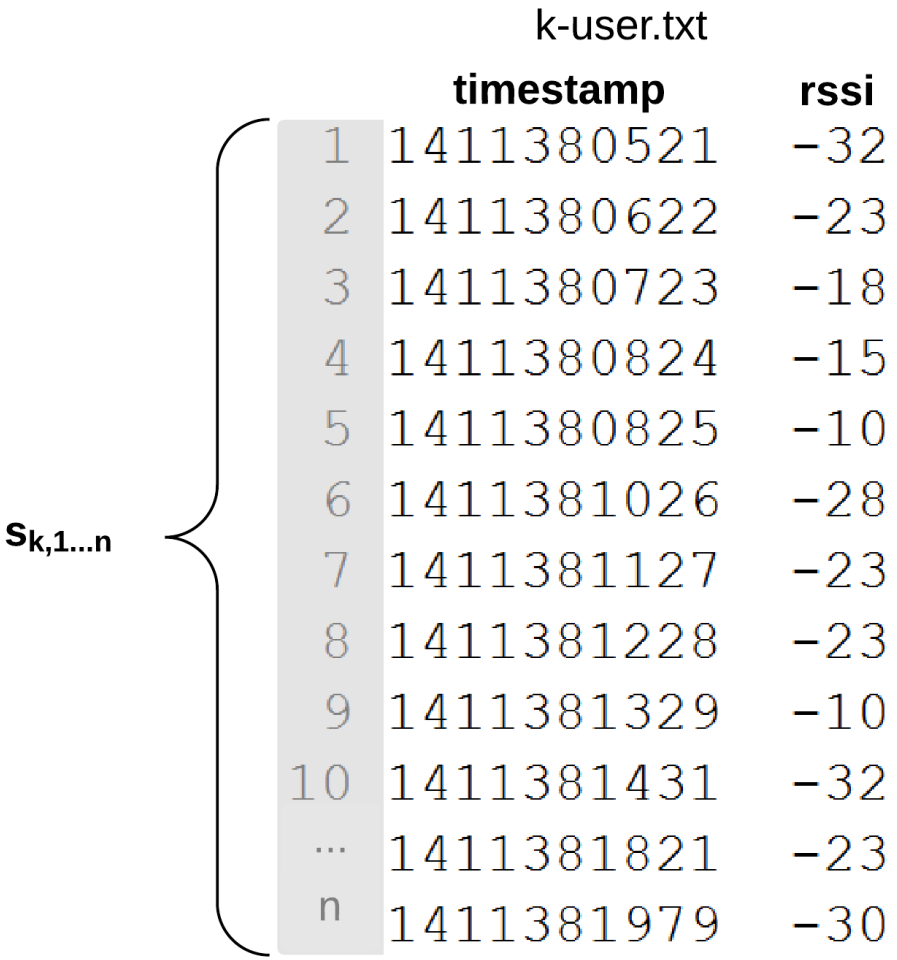
- For the **Galaxy S3** device the distribution delta arrival time of probe request frames was in the range [**27**, **34**]
- The values of high probability are **30 s**

Evaluation: Network Activity Metrics in S_2 and S_3

- Content service is used for accumulation of statistics
- It generates on the text file for each user

Metrics:

- Level of network activity: $L_k = n_k$
- Activity rate: $f_k = \frac{j-i}{t(s_{kj})-t(s_{ki})}$, $1 \leq i < j \leq n_k$
- Average value of RSSI



Evaluation: Processing Time and Memory in S_3

- Activity includes 10 speakers
- Every speech is lasted 15 minutes
- Participants use their mobile devices
- At the end of the activity, the activity analysis service runs on a separate machine: CPU 2.30GHz, RAM 4Gb, Windows 7

Performance evaluation:

- The average data processing time is **0,72 s**
- The average size of a user statistics file is **346 KB**
- **3500 KB** of free space is needed on average to store the statistics files on the content service for 10 participants

Conclusion

- Ontological model for collecting and representing the presence information about the dynamic SmartRoom users
- The architecture for the integration the information source on user presence for use in SmartRoom
- Coarse-grained model of user presence state for determining the presence levels
- Experimental evaluation the proposed solutions
- Open source code: `http://sourceforge.net/projects/smartroom/services/presence-service`

Thank you for attention