Feasibility Assessment and Roadmap for XJTLU Campus Information and Visitor Service System

(*A Test Bed for Large-Scale Location-Aware Services in SIP*)

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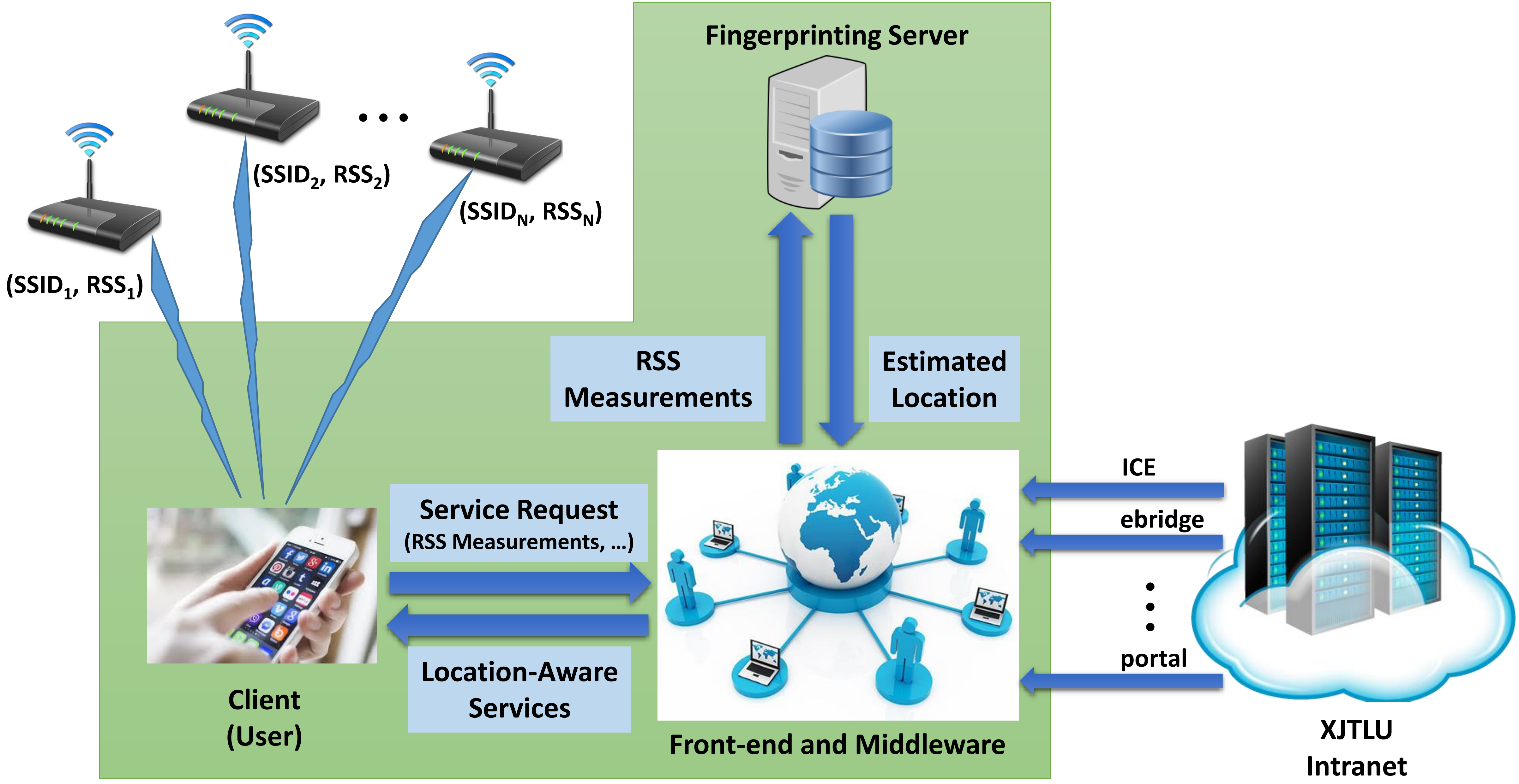
Outline

- Technical overview
- Work packages
- Roadmapping

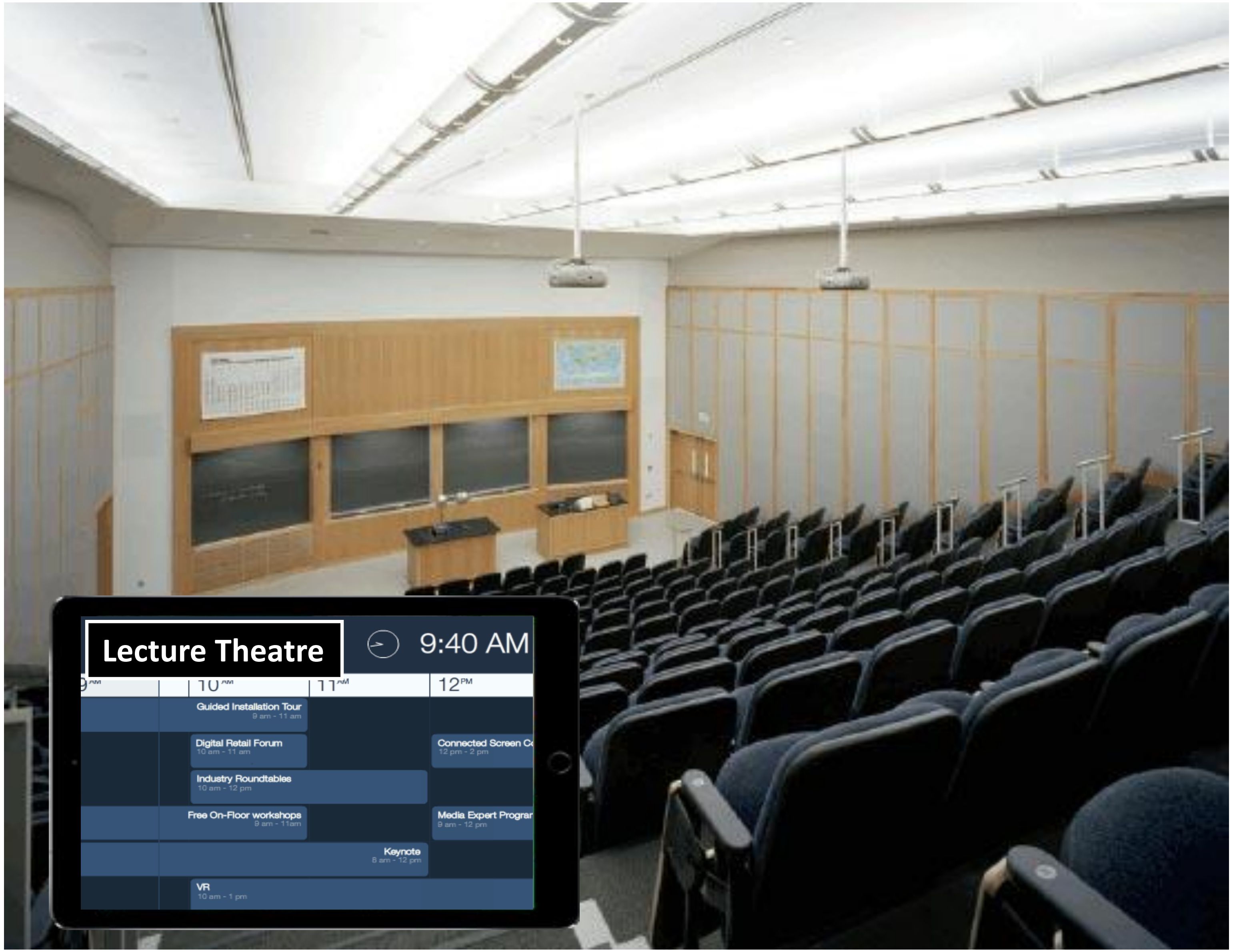
Technical Overview



XJTLU Camus Information and Visitor Service System

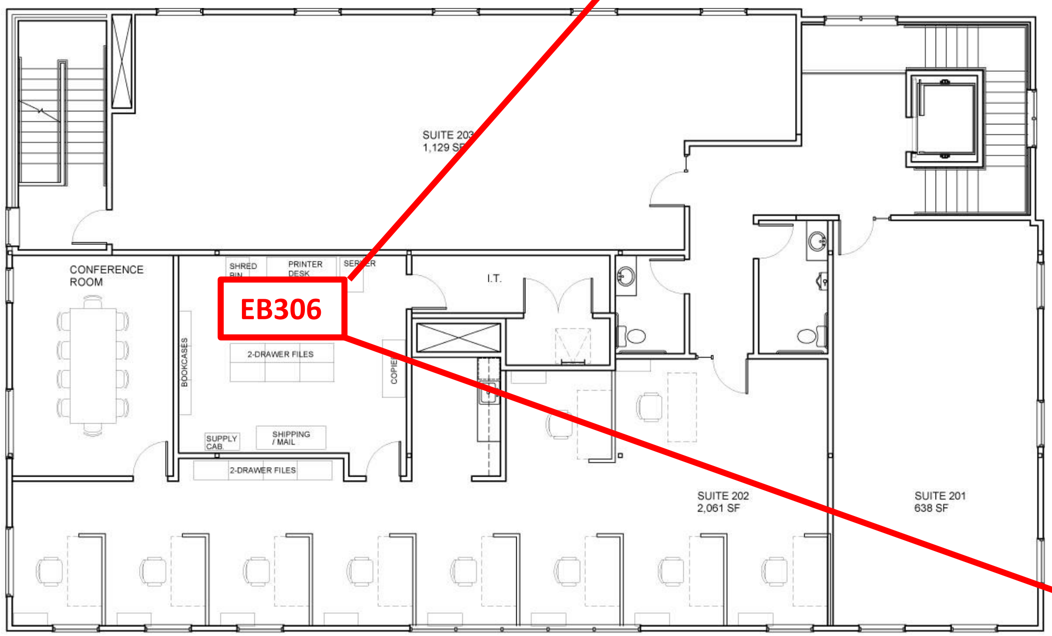
Service Example: Indoor Localisation/Navigation

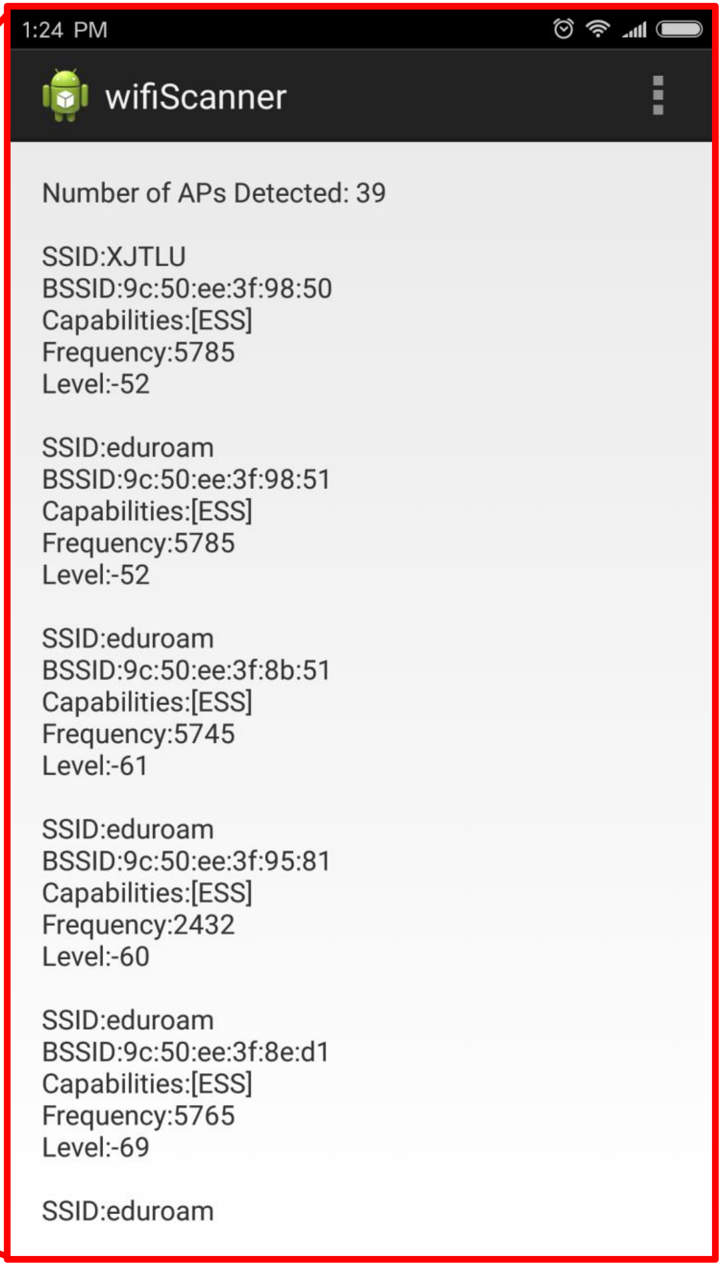
Service Example: Location-Aware Service



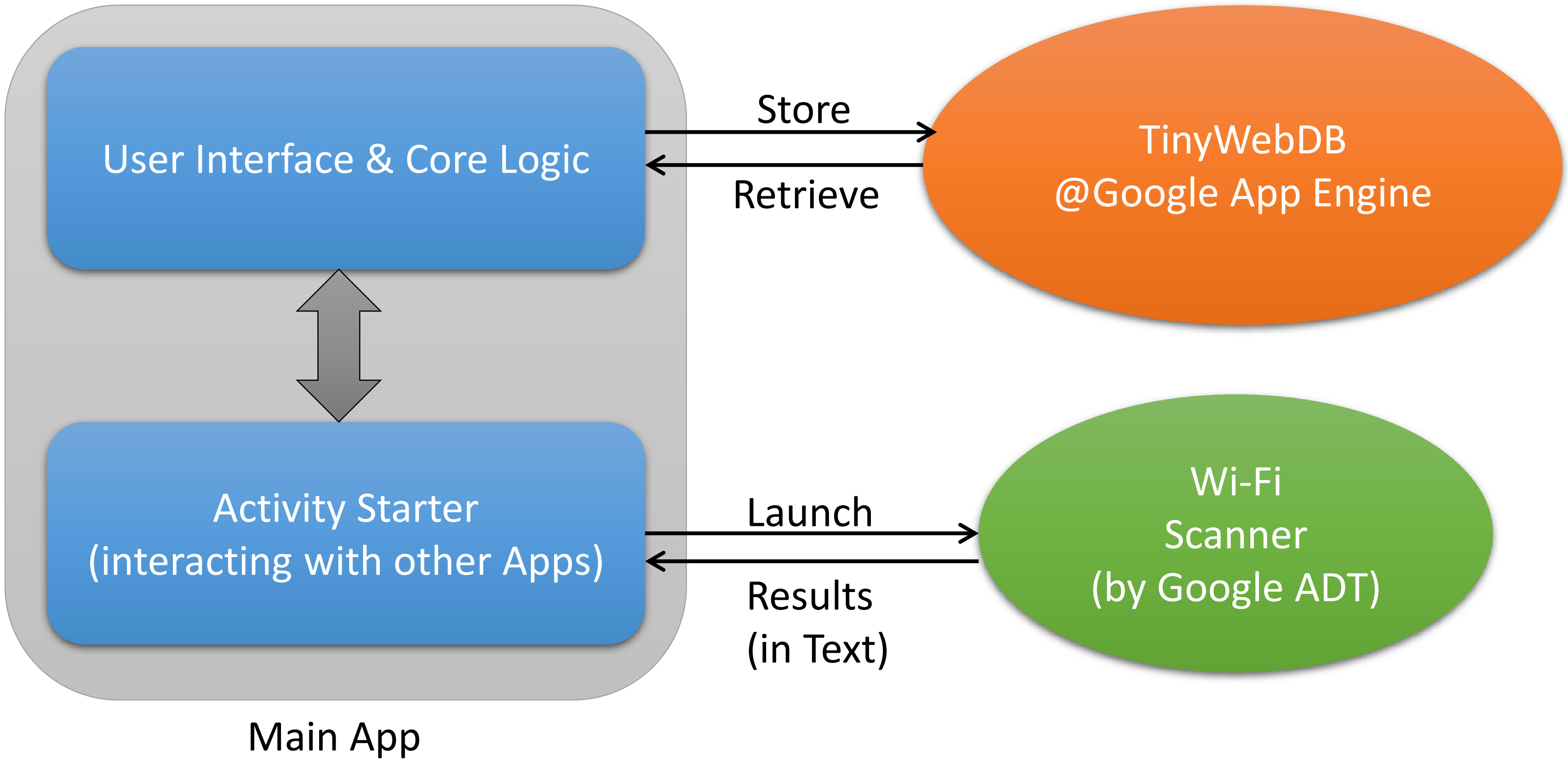
Location Fingerprint

- A tuple of $(\mathcal{L}, \mathcal{F})$
  - $\mathcal{L}$: Location information
    - Geographic coordinates or a label (e.g., “EB306”)
  - $\mathcal{F}$: Vector/function of RSSs
    - e.g., $(\rho_1, \cdots, \rho_N)^T$ where ρ_i is the RSS from i_{th} access point (AP_i).

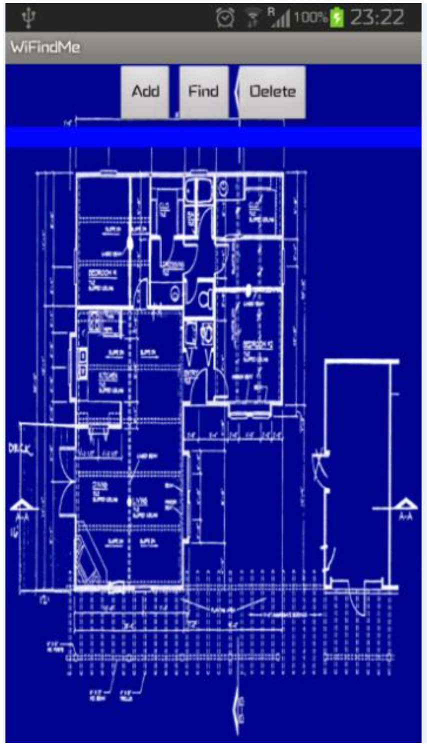




Implementation Example - 1

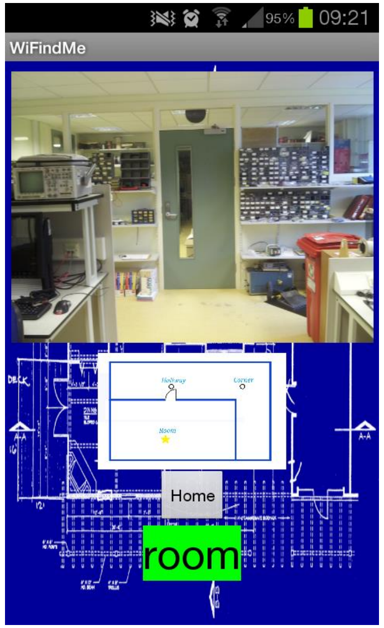


Implementation Example - 2



Start the app and
press the ‘Find’ button.

Results of Wi-Fi scanning.



Find the location and
display the picture.

Major Challenges in Large-Scale Implementation

- Scalability
- Localisation accuracy
- Non-stationarity of location fingerprints
  - Incremental/online learning algorithms with pruning/forgetting mechanisms*
- Passive vs. active location estimation
- Integration with other services
- Security/privacy issues

** R. Elwell and R. Polikar, "Incremental learning in nonstationary environments with controlled forgetting," Proc. IJCNN'09.*

Work Packages

WP1: Indoor localisation based on location fingerprinting

- Dr K Kim
- Dr Lee
- Dr Huang
- Prof Lim

WP2: Scalable and secure location-aware service system

- Prof Chen
- Dr K Kim

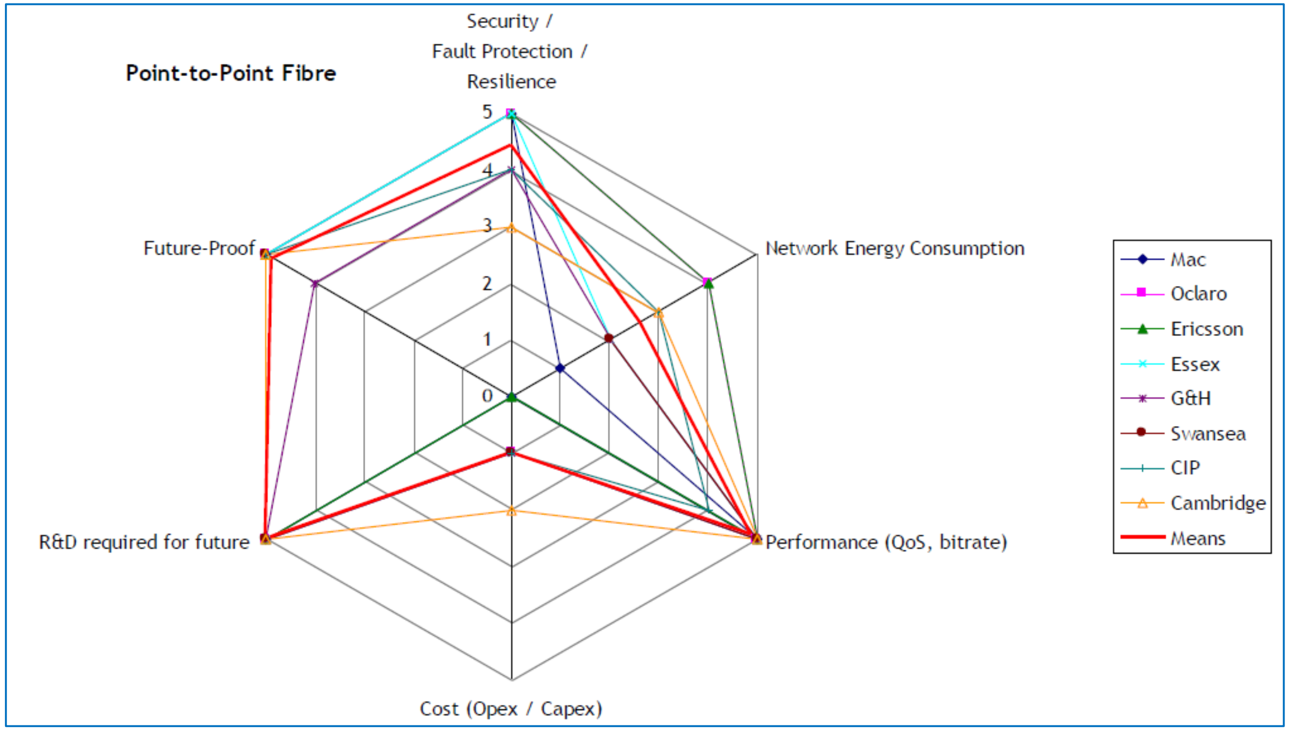
WP3: Data analysis and visualisation of users’ behaviours to improve the educational environments

- Dr J Kim
- Dr Wang
- Dr Craig

WP4: Extending and sharing with external units

- Dr Lee
- Dr K Kim

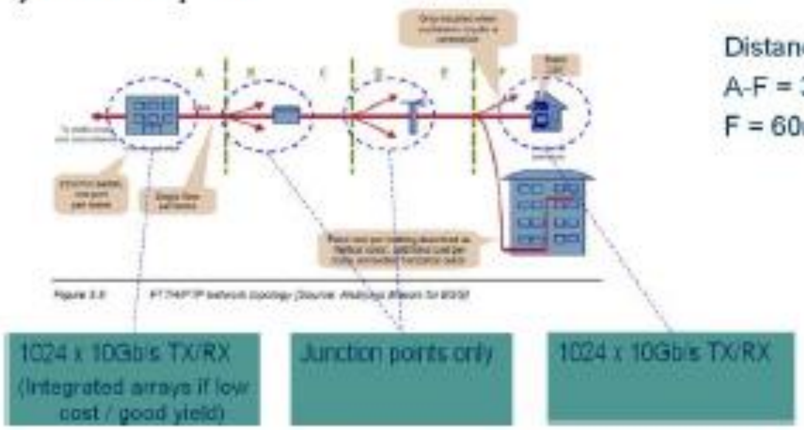
Roadmapping



Scoring Exercise

Comparative Analysis

i) Point-to-point



Distances:
A-F = 30/60km
F = 60m

Strengths

- Very future-proof and flexible. Future upgrades via TDM and WDM possible
- Good availability (independent system for each customer)
- Good performance – full line rate available all the time (limited by contention at aggregation points)
- Inherently symmetrical
- Relatively low individual component costs
- Low energy per bit (low loss in infrastructure, little processing)
- Relatively secure from hacking
- Good signal quality as little cross-talk

Weaknesses

- Highest fibre cost
- Large number of components
- Hard to provide dual-homing cost-effectively

Opportunities

- Technology already available
- Incremental cost over other solutions in green field sites is relatively low
- Easiest option for public to understand – most like utility services

Threats

- Large CO footprint – high fibre counts make inefficient use of duct space
- High energy consumption
- High capacity would cause severe core bottlenecks
- Hard to finance, so slow roll-out

Backup Slides

Wi-Fi Fingerprinting

Location Estimation

- Deterministic
  - **Nearest Neighbour Methods**
  - Neural Network Methods
- Probabilistic
  - Bayesian Inference
  - Support Vector Machine (SVM)
  - Gaussian Process Latent Variable Model (GP-LVM)

Nearest Neighbour Methods*

- A simple approach based on the notion of distance in the signal space:
  - Given a fingerprint of $(\mathcal{L}, (\rho_1, \cdots, \rho_N)^T)$ and an RSS measurement of $(s_1, \cdots, s_N)^T$, the *Euclidean distance* measure between them is defined as

$$\sqrt{\sum_{i=1}^{N} (s_i - \rho_i)^2}$$

  - Then, we find a fingerprint providing a minimum distance, $\mathcal{L}$ of which is the estimated location.

* *P. Bahl and V. N. Padmanabhan, "RADAR: An in-building RF-based user location and tracking system," Proc. of INFOCOM 2000, vol. 2, pp. 775-784, Mar. 2000.*