

Adaptive Buffering based on Handoff Prediction for Wireless Internet Continuous Services

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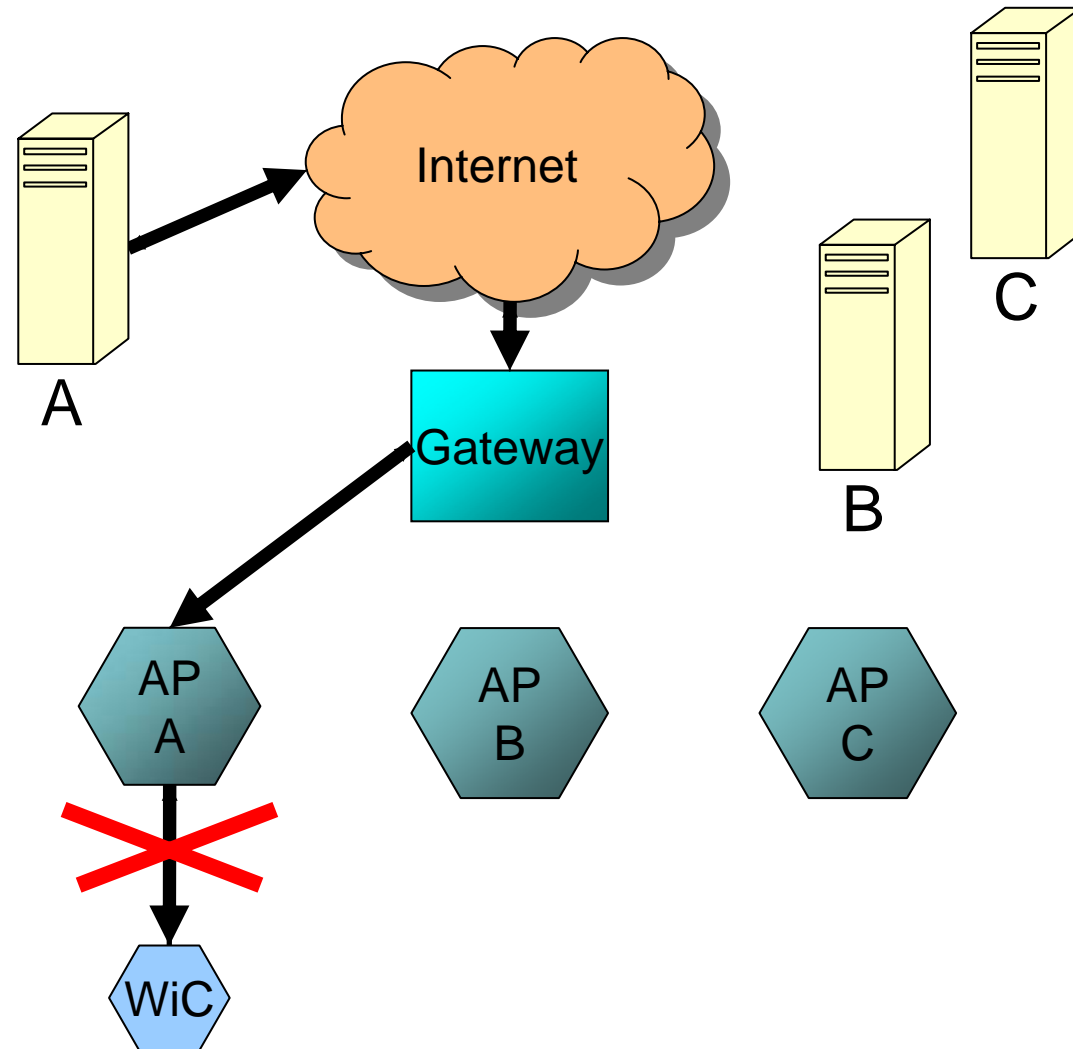
Agenda

- Wireless Internet
- Middleware for service tailoring
- Avoid continuous service interruption when a Wireless Client (WiC) performs an handover, minimizing WiC resource wasting
 - Handover Prediction
 - Adaptive Buffering
- Experimental results



The Wireless Internet

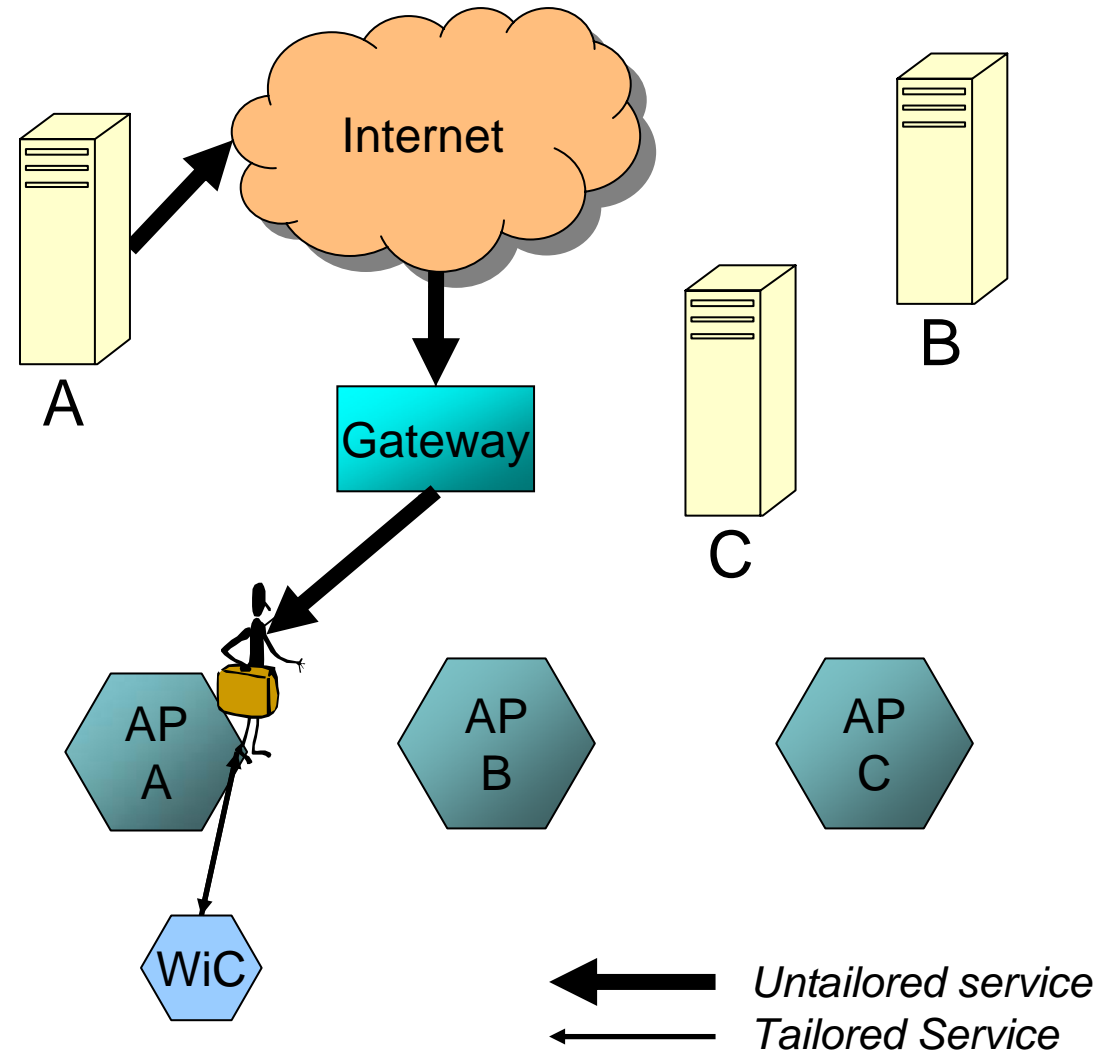
- Limited and heterogeneous WiC hardware and software
- Limited wireless bandwidth
- Limited WiC battery life





The Wireless Internet + Proxy

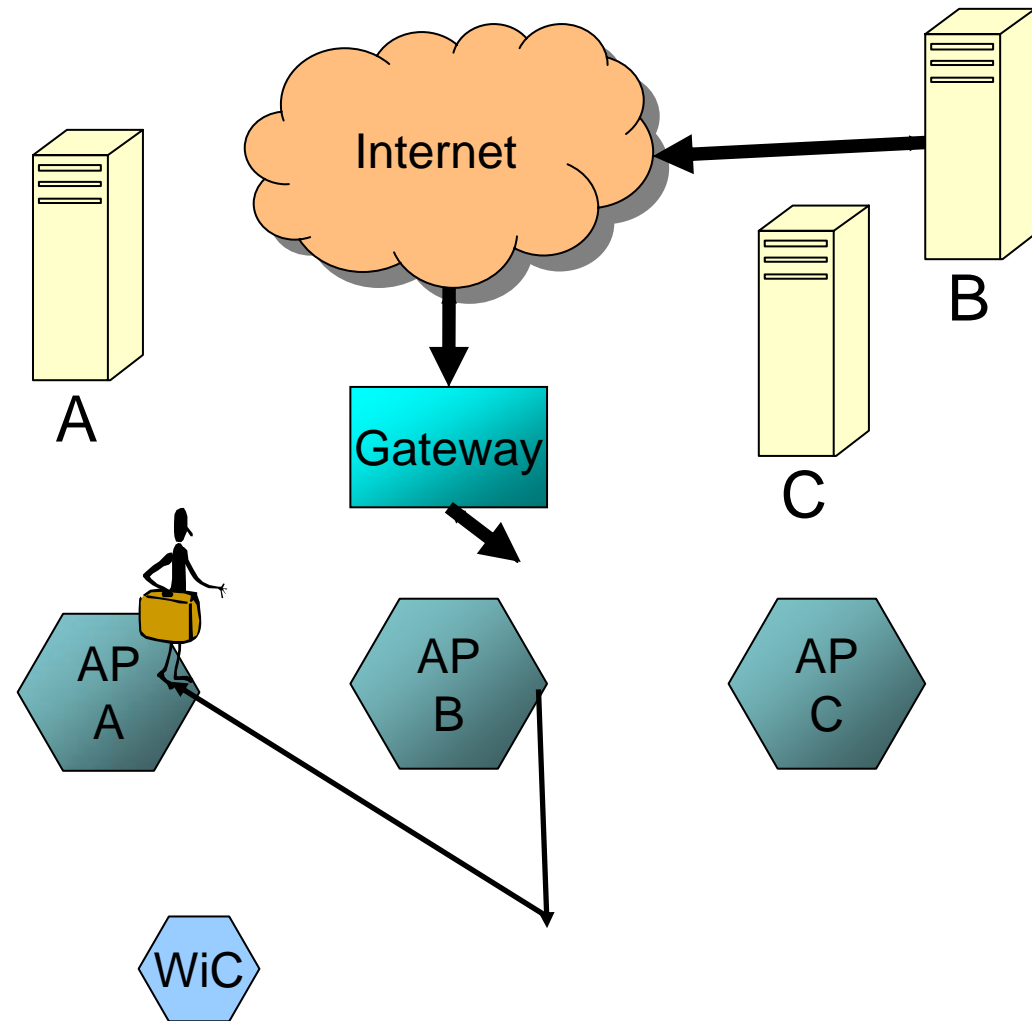
- Mobile agent based proxy tailors services to WiC software/hardware capabilities and bandwidth availability





WiC Handover

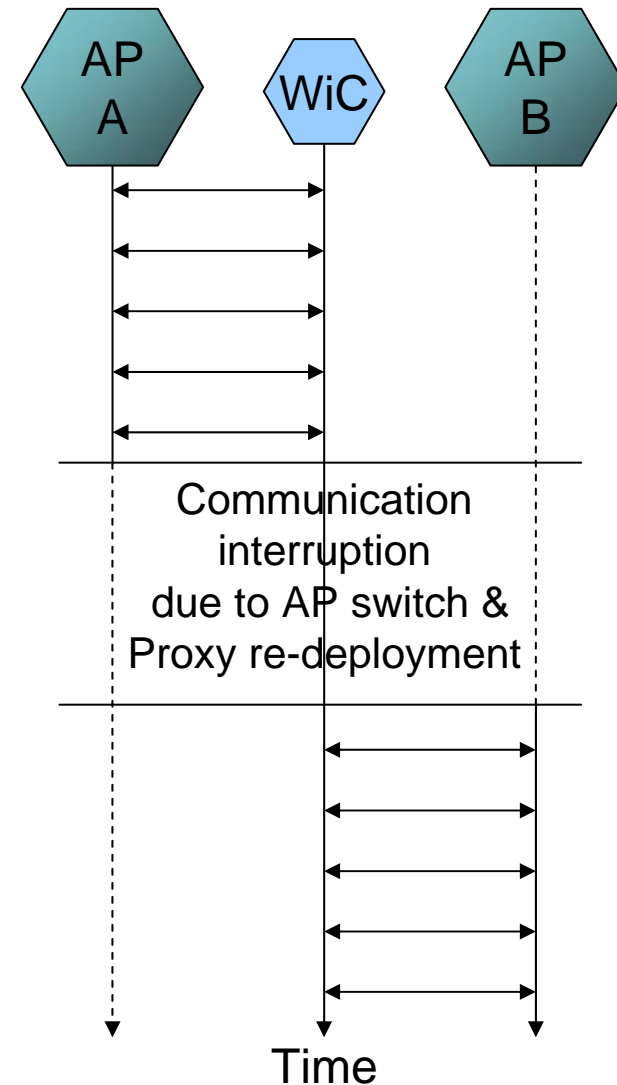
1. WiC changes AP
2. WiC triggers proxy migration
3. Proxy rebinds to service
4. Proxy supplies service to WiC





Service Interruption

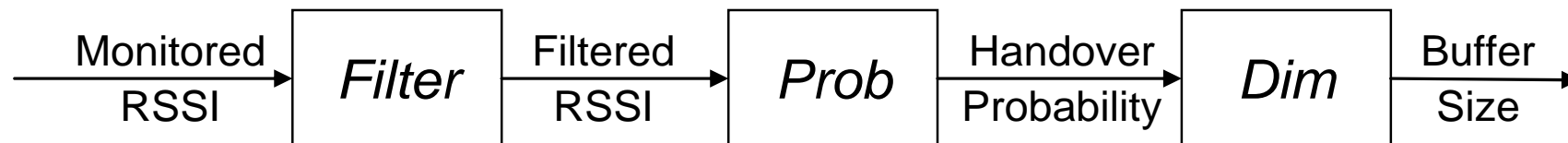
- Hard handover
 - WiC communicates with only one AP at a time
 - proxy-WiC communication link interruption during AP switch
- Tailoring Proxy re-deployment
 - proxy migration and proxy-service rebinding





Adaptive Buffering

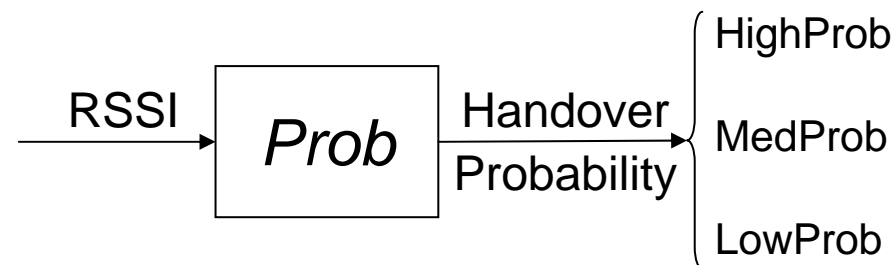
- WiC pre-fetches data to minimize service interruption due to WiC handover
- WiC limited resources suggests to pre-fetch data only when really needed, i.e. before a WiC handover
 - handover is probable: buffer at its maximum size and full
 - handover is not probable: limited buffer size





Prob Module

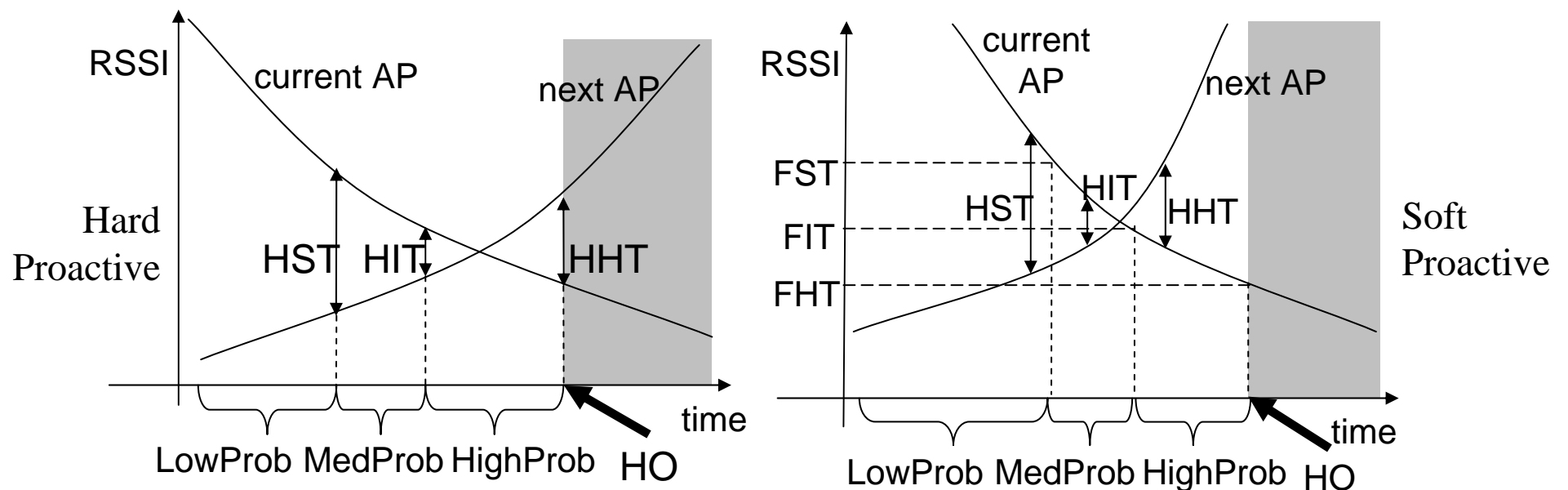
- We want to predict when WiC handover starts
 - Handover triggering based on visible AP RSSI (Received Signal Strength Indication)
- ⇒ Handover probability based on monitoring and comparing visible AP RSSI
- visible AP: AP signal reaches WiC





Prob Module: Handover Strategies

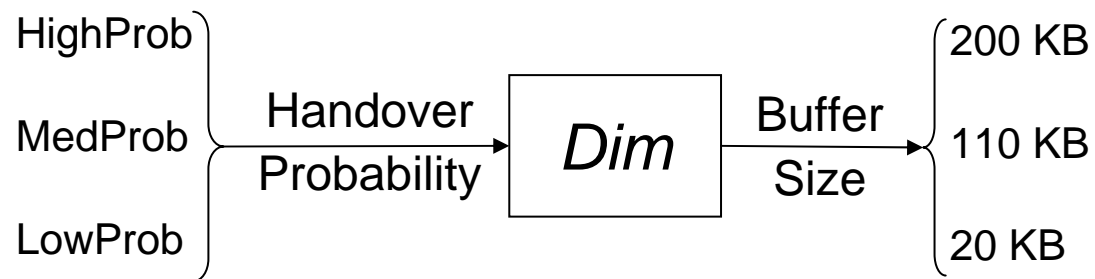
- Reactive: when signal is lost
- Proactive: before signal is lost
 - Hard Proactive: compares visible AP RSSI
 - Soft Proactive: HP + current AP RSSI is below a threshold





Dim Module

- Handover Probability \Rightarrow Buffer Size
 - HighProb \Rightarrow maximum
 - MedProb \Rightarrow (maximum+minimum)/2
 - LowProb \Rightarrow minimum
- When handover procedure starts:
 - Buffer filling \geq service bitrate * handover length
 - e.g. 187.5 KB \geq 1000 Kbit/s * 1.5s

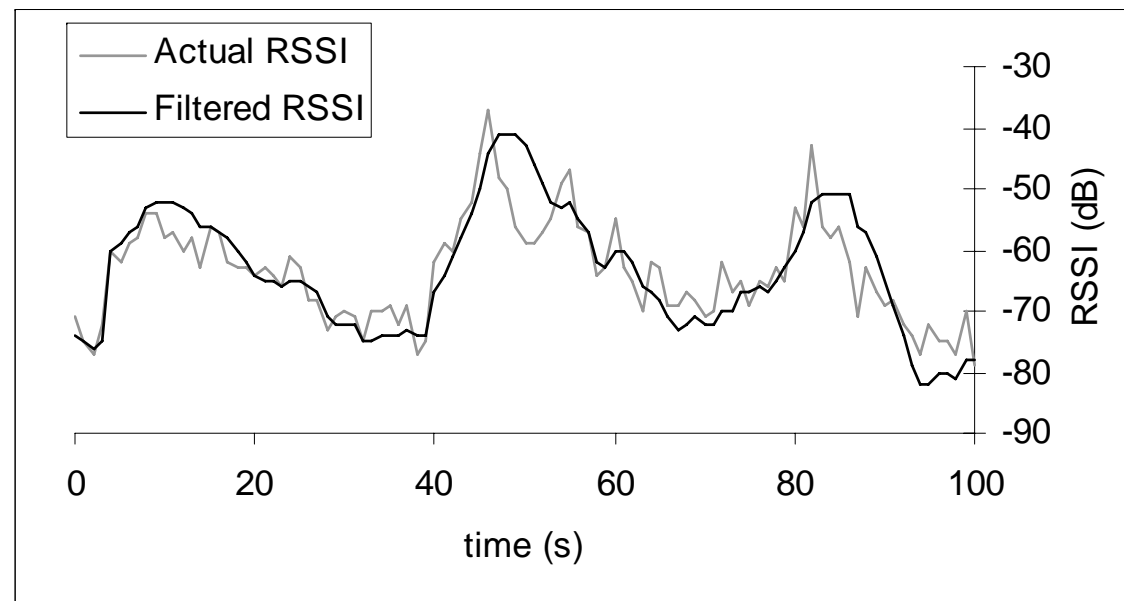




Filter Module

- Signal noise may trigger too many useless buffer size modifications
 - Filter Module exploits a simple Grey Model GM(1,1) as low-pass filter → RSSI sequence becomes more regular

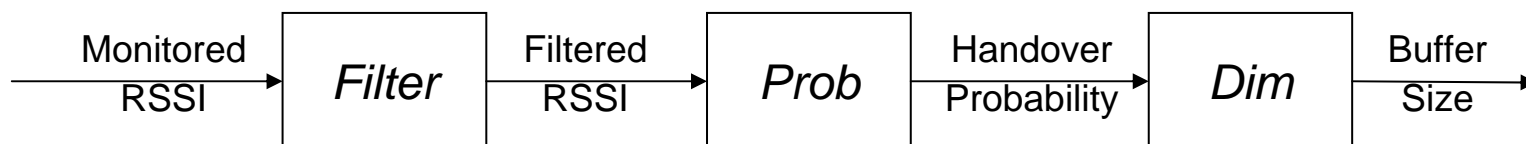
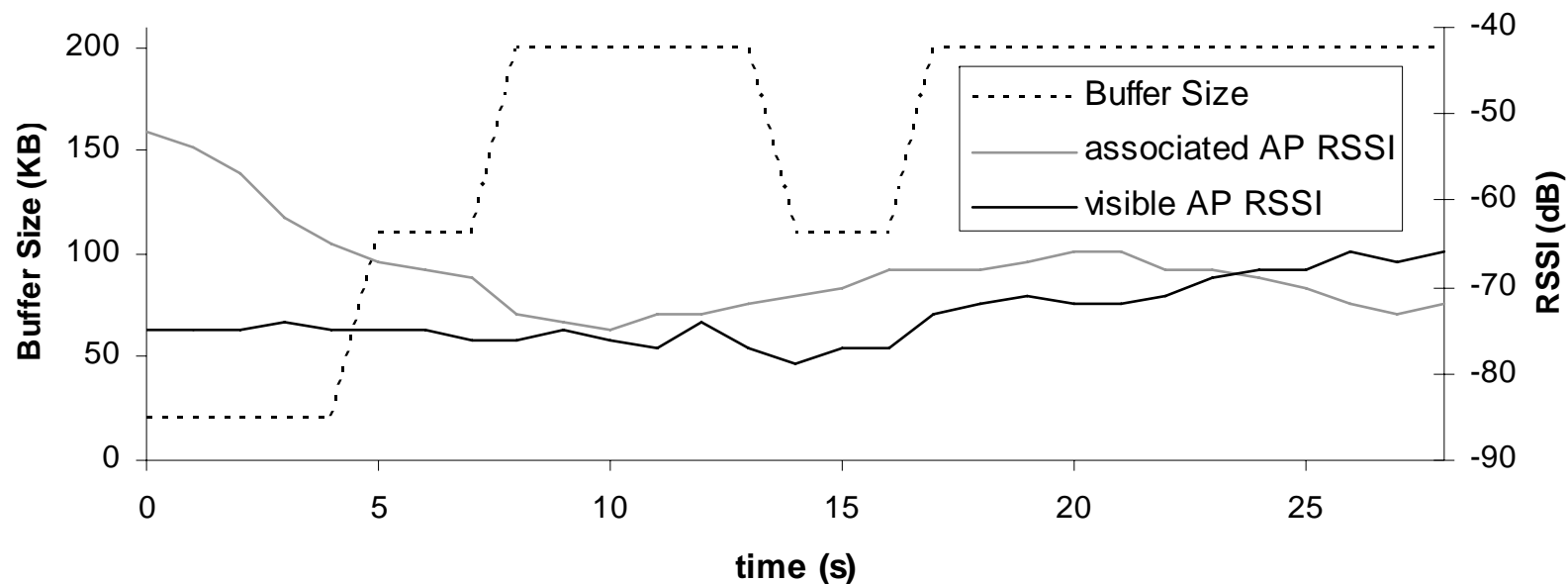
$$RSSI(i) = \left(r_1(1) - \frac{u}{a} \right) e^{-ak} + \frac{u}{a}$$





Overall Solution

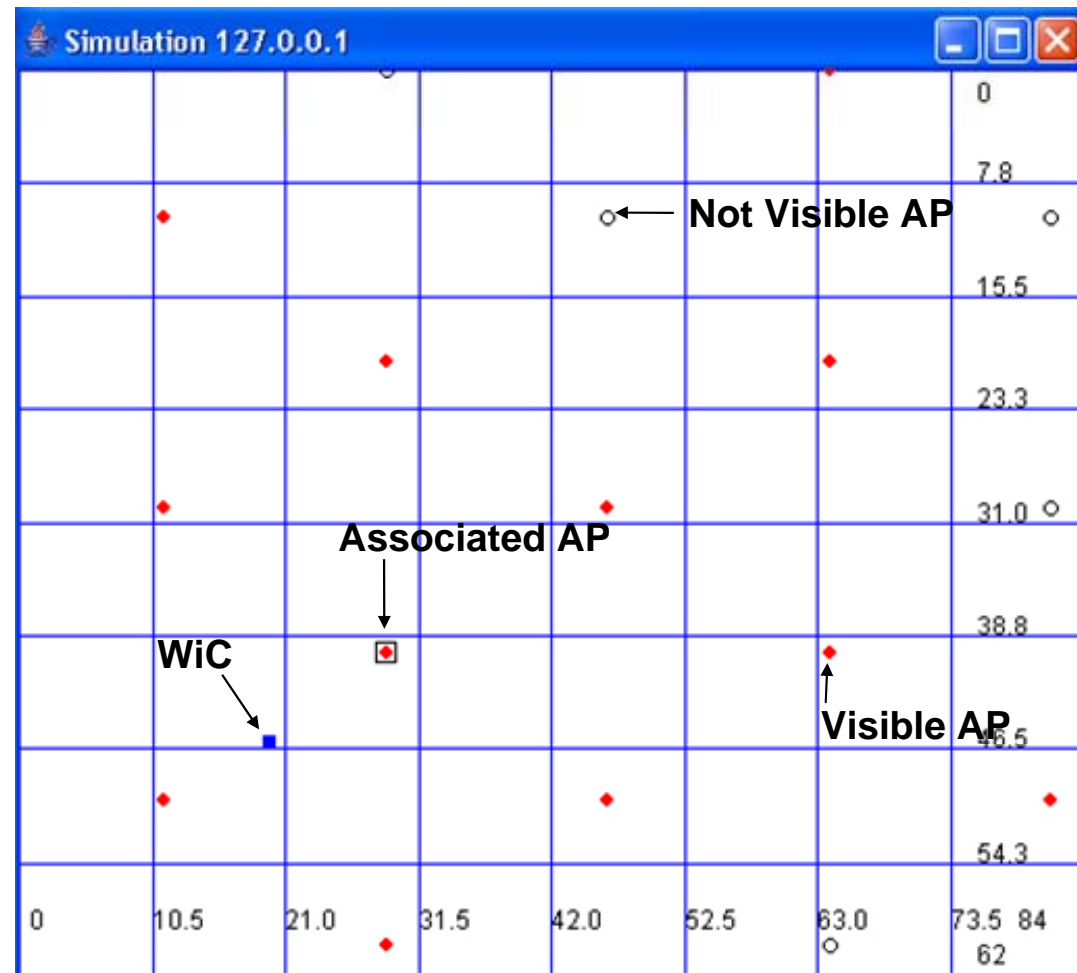
- Associated AP RSSI greater than visible AP RSSI \Rightarrow limited buffer size (20 KB)
- Visible AP RSSI comparable with associated AP RSSI \Rightarrow great buffer size (200 KB)





Simulated Environment

- Gaussian random trajectory
- WiC speed between 0.6 and 1.5 m/s
- RSSI standard deviation at 3 dB





Performance Indicators

- *Average Buffer Size (ABS)* = $\frac{1}{T} \int_0^T BS(t) dt$

- *Average Buffer Duration (ABD)* = $\frac{1}{T} \int_0^T BD(t) dt$

- *Successful Handover (SH%)* = $\left(1 - \frac{IS}{NH}\right) * 100$
 - *IS* number of handovers with interrupted service
 - *NH* number of handovers



Experimental Results

- Proposed solution has good performance
 - Memory saving: more than 30%
 - Handovers without service interruption: more than 90%
- GM(1,1) adoption allows less buffer modifications

Handover Strategy	Filter Module	ABS (KB)	SH_%	ABD (s)
Hard Proactive	Identity	140	92.1	2.80
	GM(1,1)	133	92.8	5.20
Soft Proactive	Identity	145	91.6	2.79
	GM(1,1)	138	97.5	5.66



Conclusions & Ongoing work

- Supporting provisioning of personalized services without interruptions even if WiC performs an handover
- WiC resource saving through **handover prediction** and **adaptive buffering**
 - WiC computes handover probability in a lightweight, portable, and completely decentralized manner, only based on RSSI
- Evaluate performance of other filters
 - Kalman filter, Discrete Fourier Transform...



Any question?



■ Acknowledgements

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■ Web references for software and additional documents

- <http://lia.deis.unibo.it/Research/SOMA/SmartBuffer/>
- <http://lia.deis.unibo.it/Research/SOMA/MobilityPrediction/>
- <http://lia.deis.unibo.it/Staff/CarloGiannelli/>