

Efficiently Managing Location Information with Privacy Requirements in Wi-Fi Networks: a Middleware Approach

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Agenda

- User privacy in Location Based Services
 - location information management
- Middleware for privacy-enabled LBS with network traffic concern:
 - request dropping
 - location obfuscation
- Experimental Results



Location Based Services

- Mobile devices + Wireless technologies → Positioning systems (without additional hardware)
- Location Based Services (LBSs)
 - virtual museum assistance
 - service discovery
- Location information
 - symbolic model with variable granularity

Location ID	Location Information	Granularity
11	Italy, Tuscany, Siena	3
12	Italy, Emilia, Bologna, EngFaculty	4



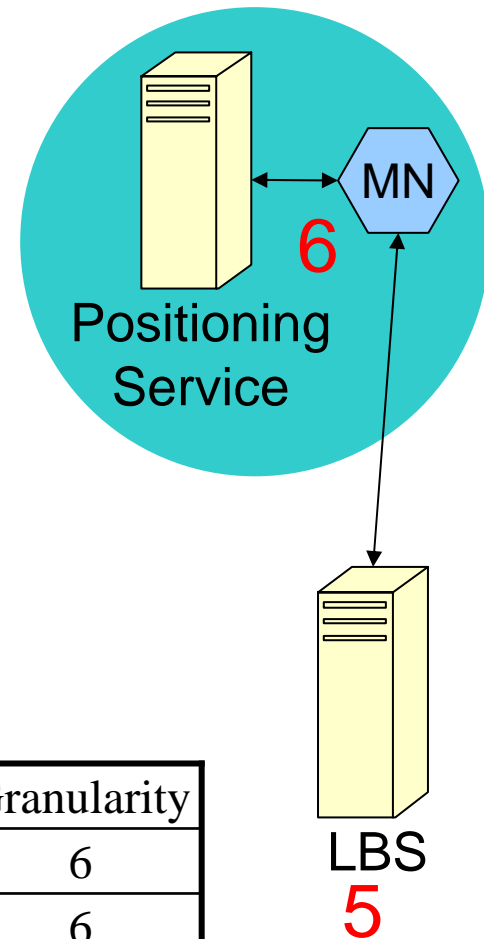
User privacy issue

- User privacy is a primary issue:
 - location disclosure – user privacy
 - location information disclosed only when needed and only at the proper detail level (granularity)
- When sending information to LBS?
- Which information to LBS?
 - user privacy/LBS requirements



Request Dropping

- Divulgate location and request services only when needed
 - client requests services at each location change: more services than needed
 - client performs request dropping



Location ID	Location Information	Granularity
11	Italy, Emilia, Bologna, EngFaculty, Lab2, PhDZone	6
12	Italy, Emilia, Bologna, EngFaculty, Lab2, Office	6
13	Italy, Emilia, Bologna, EngFaculty, Lab2	5



Location Obfuscation & Service filtering

- Location information obfuscation:
 - client discloses location information tacking into consideration user privacy requirement
- Service filtering
 - LBS provides information about managed locations
 - location obfuscation implies more descriptions at each service request
 - LBS response filtering

Location obfuscation

Location ID	Location Information	Granularity
11	Italy, Emilia, Bologna, EngFaculty, Lab	5
12	Italy, Emilia, Bologna, EngFaculty, Comm Lab	5
13	Italy, Emilia, Bologna, EngFaculty	4



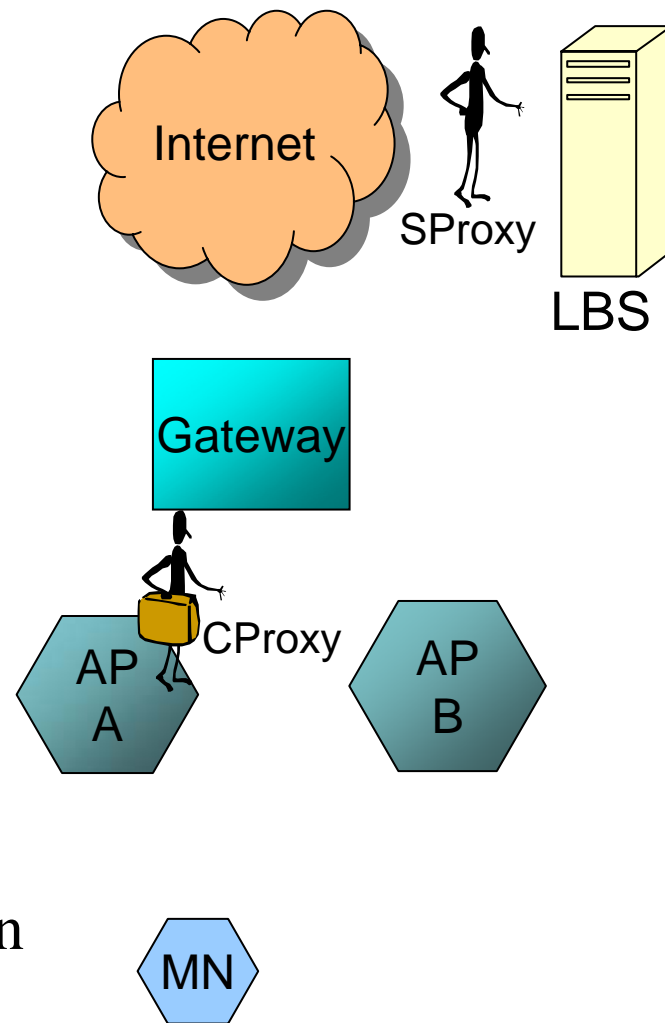
Two-level proxy-based middleware

- Proposed solution performs
 - request dropping
 - location obfuscation
 - service filtering
- Two-level proxy-based middleware
 - no changes to application client and LBS
 - no additional computation on MN
 - a proxy on behalf of MN, a proxy on behalf of LBS



Middleware architecture

- CProxy
 - close to the currently associated AP
 - knows user privacy requirement
 - performs request dropping
 - migrates to follow MN
- SProxy
 - close to LBS
 - knows LBS location granularity requirement
 - hides to LBS CProxy/MN identity: user anonymity
- CProxy and SProxy share LBS and user requirements
- Either CProxy or SProxy performs location obfuscation to satisfy LBS/user privacy requirements



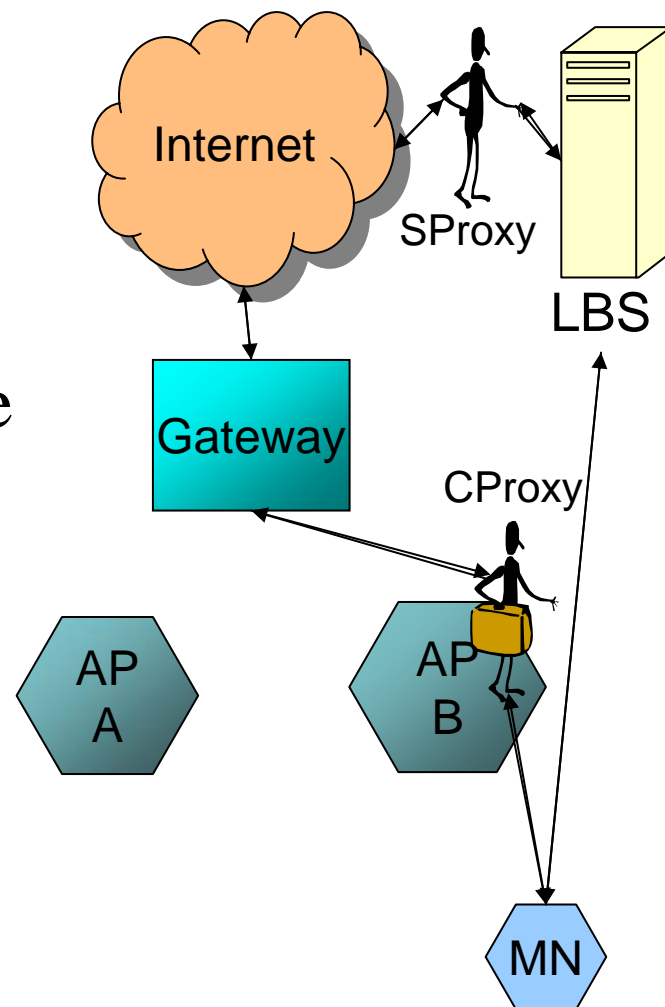
Working modes (1)

■ PrivacyOff

- middleware not exploited
- no location obfuscation for user
privacy requirements → no service filtering needed
- request dropping unavailable

■ Anonymous

- middleware exploited
- request dropping





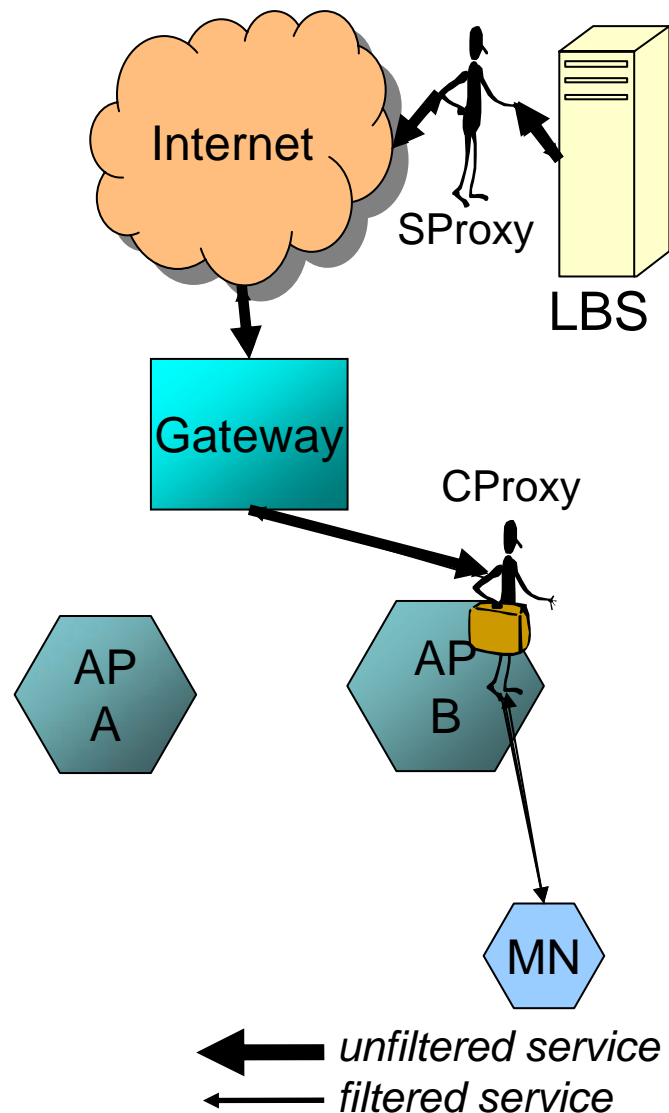
Working modes (2)

■ SSPM: Server Side Privacy Management

- SProxy performs location obfuscation and service filtering
- service filtering close to LBS

■ CSPM: Client Side Privacy Management

- as SSPM but CProxy in charge of location obfuscation and service filtering





Cumulative Service Time

■ Cumulative Service Time (CST):

- sum of service response times in the current and already visited locations
- underlines middleware performance in a typical LBS scenario with multiple client requests

	Granularity
Location	6
LBS	5
User privacy	4

■ Location information granularity greater than LBS one

Location ID	Location Information
11	Italy, Emilia, Bologna, EngFaculty, Lab2, PhDZone
12	Italy, Emilia, Bologna, EngFaculty, Lab2, Office
13	Italy, Emilia, Bologna, EngFaculty, Lab2, StudZone
14	Italy, Emilia, Bologna, EngFaculty, CommLab, BTStation
15	Italy, Emilia, Bologna, EngFaculty, CommLab, Admin
16	Italy, Emilia, Bologna, MathFaculty, Floor1, Room12
17	Italy, Emilia, Bologna, MathFaculty, Floor1, Room5



Experimental results

■ PrivacyOff

- CST grows linearly

■ Anonymous

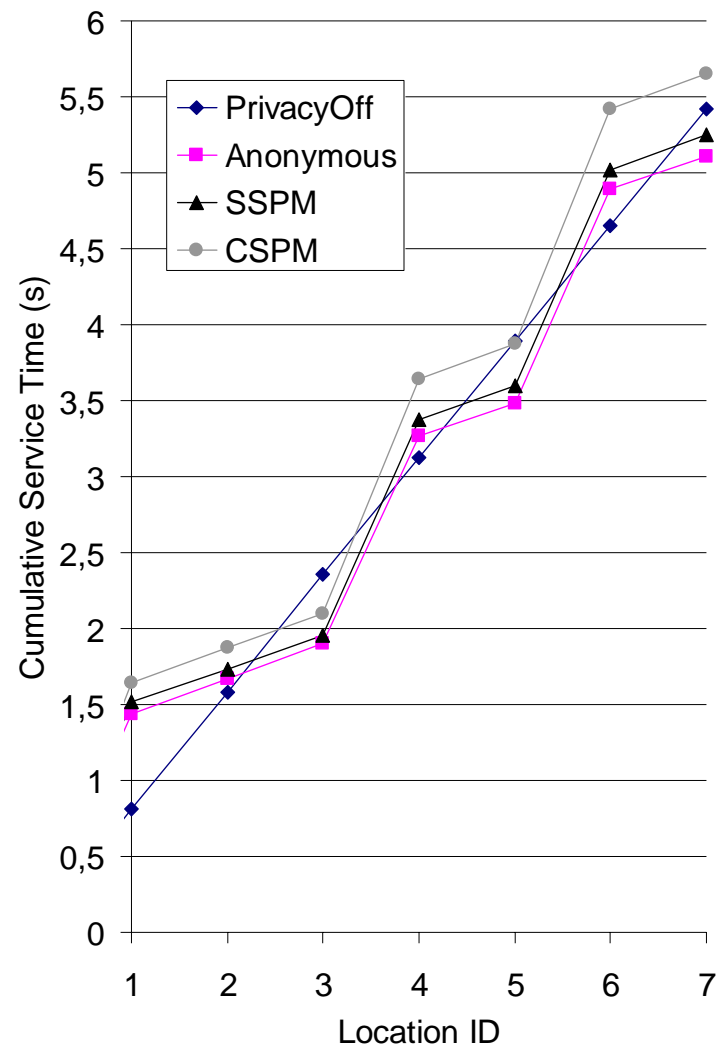
- 11, 14, 16 great service delay
- 12, 13, 15, 17 request dropping

■ SSPM

- Service filtering on the server-side

■ CSPM

- Service filtering on the client-side
- worse performance, greater user privacy





Conclusions & Ongoing Work

- A middleware solution for privacy-enabled LBS simplifies the design and implementation of more user-trusted LBSs
- A two-level proxy-based architecture to provide
 - user anonymity
 - user privacy
 - limited traffic overhead
- Proposed middleware performance comparable with a simpler privacy-unaware C/S solution
- CProxy/SProxy not just for request dropping and location obfuscation:
 - SProxy caches requests for multiple clients
 - CProxy caches for multiple requests from the same client



Any question?



■ Acknowledgements

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