Location-Aware Information Services

Stefano Spaccapietra

Ecole Polytechnique Fédérale de Lausanne (EPFL)

Database Laboratory

School of Information and Communication Science

http://lbd.epfl.ch

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LBS today: *Right on the spot information* Delivery

- An LBS is a Service: It responds to user requests, acting as a mediator between a generally unknown, usually mobile, user and “local” data sources or service providers
- Location-Based: Its knowledge covers a limited region in geographical space
- Location-Aware: It takes into account where you are
- Mostly, it is an information-providing service
  - Where is the nearest cash dispenser?
- It may also perform as an intelligent agent
  - Can you book me a seat at the concert tonight?

LBS tomorrow: *Knowledgeable Information* Delivery

- Space-awareness (current LBS)
  - Nearest cash dispenser
- Time-awareness
  - Do not suggest visiting a market on days it is closed
  - Omit out-of-town spots if the user has only half a day free
- Context-awareness (contextualization)
  - On rainy days, suggest a museum rather than a park
- User-awareness (personalization)
  - If user is on a business trip, suggest taking a taxi rather than a combination of public transports
- Service-awareness (focus)
  - do not promise information you do not have

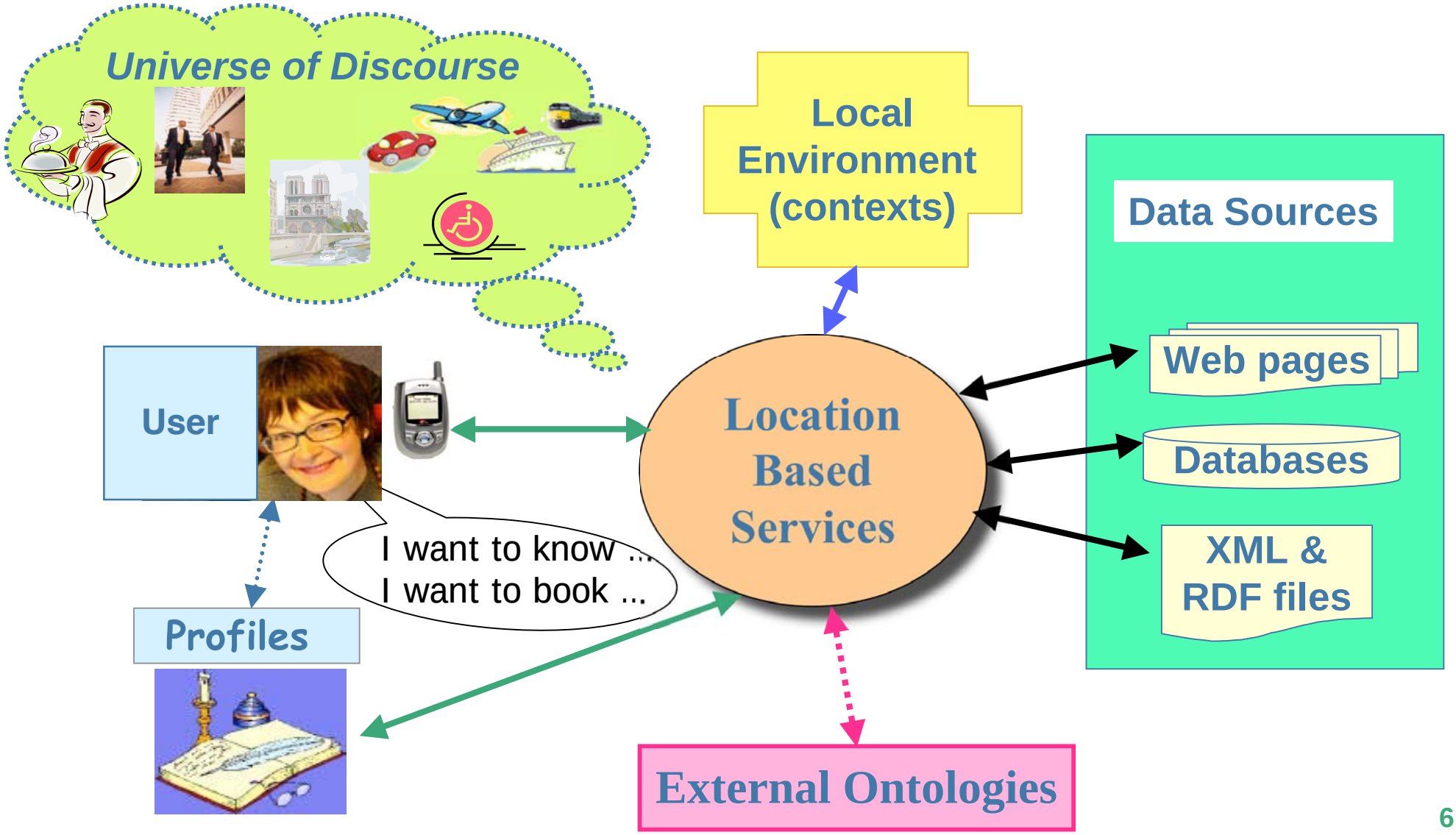
Personalization facets: info for you

- Selecting a subset of the objects of interest
  - Select nearby restaurants by taking into account your preferences for cuisine
- Choosing specific information
  - Adapt information on the church to the level of detail that is appropriate to your knowledge of the topic
- Evaluating predicates
  - Define the meaning of “nearby” depending on your habits
    - User dislikes to walk: nearby = less than 5’ walk
    - User likes to walk: nearby = less than 15’ walk
    - User takes her car: nearby = less than 10’ drive)

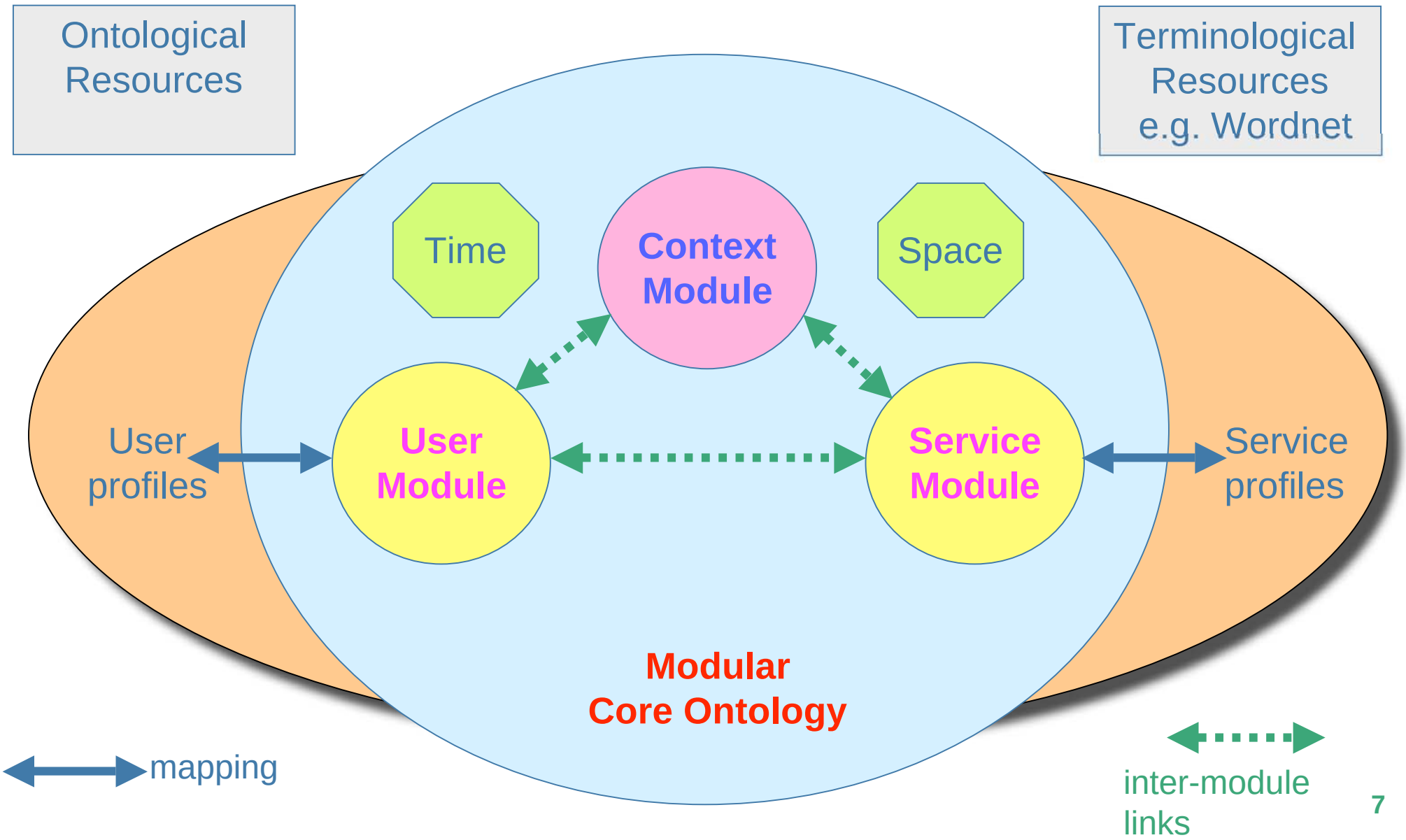
Contextualization facets: info for where you are in the situation you are

- Query refinement
  - When looking for transport means to join a meeting, prefer nearest metro or train if currently under severe traffic conditions
    - duration of a trip on roads depends on traffic conditions
  - When looking for transport means to join a meeting,
    - if in Switzerland select a transportation timing that takes you at the meeting slightly before its opening
    - if in Italy, select metro, a transportation timing that takes you at the meeting within half an hour from its opening
    - when it is appropriate to join a rendez-vous depends on local socio-cultural rules
  - When looking for restaurants on a rainy day, ignore user preference for restaurants with outdoor garden
    - outdoor activities normally require good weather conditions

An Architecture for knowledgeable LBS



Data Infrastructure



Constructing the Modules

Incremental approach:

- Start with an imported kernel (domain ontology)
- Refine the kernel to restrict it to what is locally relevant
- Enrich the kernel by incorporating new knowledge:
  - new service profiles provided by the sources
  - new user profiles provided by the users
- Expand the terminology with synonyms etc.
- Expand the knowledge using external ontologies
- Keep the local focus
- Derive the level of detail that appropriately characterizes the concepts in the modules

Context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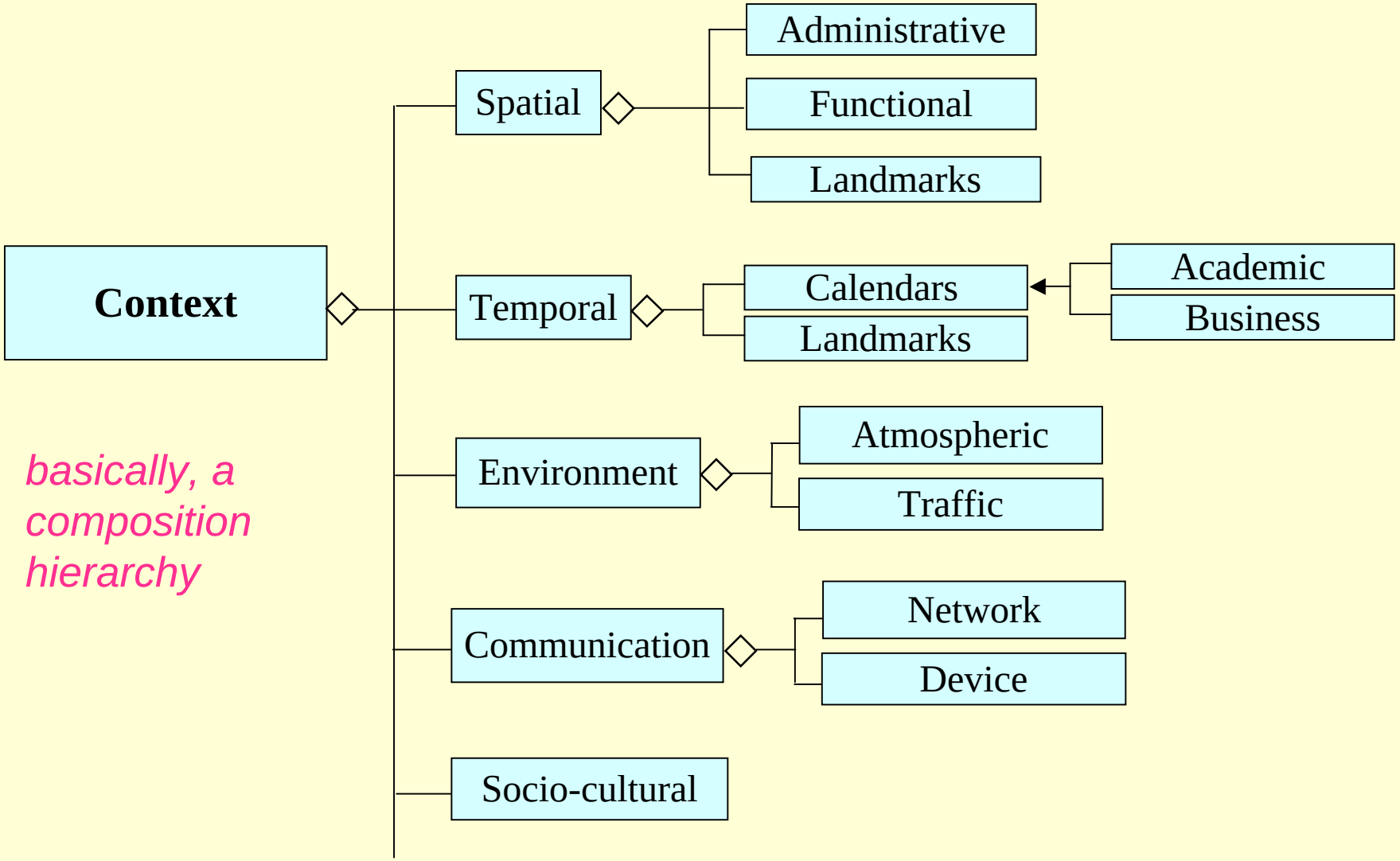
What's Context?

- **Context:** where, when, who, why, what, how (Schilit et al., 1994)
- **Context:** any information that can be used to characterize the situation of any entity. An entity is a person, place, or object, that is considered relevant to the interaction between a user and an application, including the user and the application themselves (Anind K.Dey, 2000)
- Low-level contexts:
  - location, time, nearby objects, networking configurations, orientation, environment (light, temperature, pressure, sound, pollution, etc.)
- High-level contexts:
  - social context (e.g., social status of the user or of the location)
  - personal context (e.g., user's intention and preferences).

Context Data for an LBS

- Describes the current "situation" of the real world of interest
- Any information that may lead to modifying a user query given the current situation and is not specific to a user or to a service
- Context data comes from all sorts of sensors, from the available sources (e.g. databases of the local tourist office and local newspapers, web pages about local facilities), from an analysis of the user behaviour (e.g. current activity), etc.
- Can be enriched using knowledge from generic and local ontologies
  - E..g.: rain --> bad weather, time > 6:30pm --> shops closed

A Skeleton for the Context Module



basically, a composition hierarchy

Example: Environmental Data

Environmental data for Lausanne

Date: 27.9.2007
Weekday: Thursday
Time: 11h00
Weather: sunny
Temperature: +13 Celsius
Humidity: 53%
Weather forecast: good, warming
Pollution level: medium
Snow: none
Traffic: fluid

Environmental data for user (in a room)

Date: 27.9.2007
Time: 11h00
Temperature: +20 Celsius
Humidity: 40%
Light: shadow
Pollution level: medium
Noise level: medium

Is Context Data Relevant?

- Who needs to know about traffic conditions?
  - road-based transportation services, trip planners, delivery services, …
- How does the LBS know when traffic conditions are relevant?
  - "relevance" link between service and context modules
  - a relevance link connects a service with the context elements on which the service "depends"
    - e.g. bus transportation services depend on traffic conditions (to compute durations), local events (to look for alternate routes if needed), and the day of the week (to refer to the appropriate schedule). "Depend" here means the services need this context information to provide contextualized answers.
    - availability of services may depend on what is the current day of the week (e.g. museums in France are closed on Tuesday). "Depend" here means there is a precondition for using the service. The precondition may be stated as a predicate on the current temporal context.

Context Data and User Profile

- User queries need to be contextualized and personalized.
- Personal preferences may depend on context
  - e.g. a preference for outdoor-sitting in restaurants is only relevant if the weather is currently fine
  - outdoor-sitting is a concept that is relevant in a certain context; it needs to be linked to atmospheric context. To parallel with services, we could say the link is about the "availability" of this user preference.
- Outcome:
  - inter-module relevance links are used either as a filter (to determine what has to be considered ("availability")) or as an import means (to transfer knowledge so that the service process becomes knowledgeable)

User Profiles

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Personalization => User Profiling

- Basically, a set of properties that characterize the user (e.g., age class, profession) or express user's preferences and priorities (e.g., domains of interest, preferred cuisine style): <attribute,value> pairs
- Highly context-dependent: many profiles
- No standard, no theory

Example Profile 1 for Stefano:
Activity: **Tourist**
Profession: {professor, employee, academic}
Age: senior Gender: male
Nationality: French, Swiss
Income: comfortable
Interest: art, culture, hiking, cinema
Languages: French, English, Italian
FoodPreference: very good to good
Cuisine: Japanese, Thai, Arabic, Argentinean

Example Profile 2 for Stefano:

Activity: **Professional**
Profession: {computer scientist, professor}
Age: senior
Interest: databases, ontologies, semantic web
Languages: French, English, Italian
Memberships: ACM, IEEE, IFIP, SI, DBTA

Using User Profiles

- To make queries more focused
- To present retrieval results in user's order of preference
  - Query reformulation examples

"where can I buy a souvenir?" **+ income: moderate**

=> *"give me a nearby department store which sells souvenirs"*

"which movie could I see tonight?" **+ languages: E / G / F**

+ preferences.movie.type + preferences.movie.rating

=> *select a movie in English/German/French which*

is not an "action" movie and was rated at least "good"

Complex User Profile Structures

- Beyond < attribute, value > pairs …..
  - An attribute may be multivalued
  - An attribute may be structured (with embedded sub-properties)
    - E.g., interest [domain, level-of-expertise]
  - An attribute may have a hierarchy of values (i.e., values at different levels of detail)
    - E.g.: Interest (music (rock, tango), movie (action-movie (karate-movie)))
- Dependencies may exist between attributes
  - E.g., income => hotel category
- Rules stating what the attribute is useful for
  - E.g., income has impact on things implying a payment (buy), but has no impact on preferences in things free or inexpensive

Abstracting User Details

- User profiles are mapped to the LBS ontological module about users
- The user module describes an abstraction of user profiles
- This abstraction provides directives (patterns) for query reformulation
- The patterns are evaluated against the suitable profile of the querying user

Service Profiles

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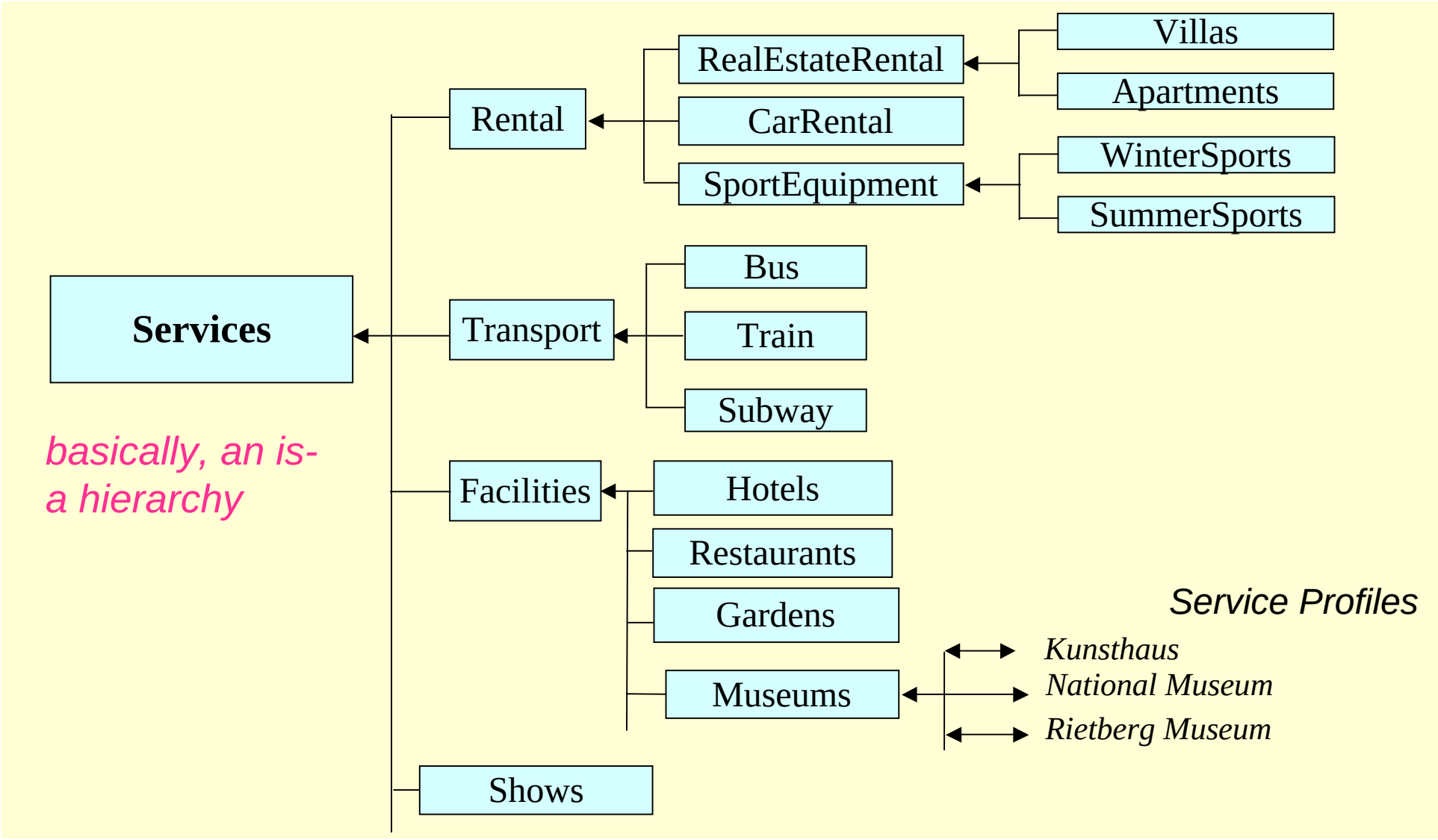
Services from Multiple Data Sources

- "Local" available sources
  - e.g., for a tourist in Zürich, Uetikon and Nurensdorf tourism information is also considered locally relevant, but not Lausanne information
- Heterogeneity: Structured, unstructured, browsable / queriable
  - e.g., public local databases, local and generic Web services, Web pages
- Diverse knowledge extraction strategies, but no extraction tools for space and time
- Homogenization: describe each source as a set of services
  - Semantics: Service Profiles (OWL-S, WSML, WSMO)
  - Syntax: WSDL, UDDI, SOAP,…, GML (Geographical Markup Language)
- Service profiles are mapped to (and abstracted by) the LBS ontological module about services

Conditional services

- A service may be available only in conjunction with other services, e.g.
  - to obtain a visa you must first obtain an id document
  - => pre & post conditions
- A service may be available only for given persons
  - to access a swimming pool at certain times you must have membership into the swimming club or hold an American Express credit card
- A service may be available only in given contexts
  - in Switzerland, shops are closed on August 1st
  - a special bus to a nature park only runs on sunny days

A Skeleton for a Service Module



Queries

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Query Formulation Techniques

- Natural Language
  - Where in Zürich tomorrow can I buy a MacIntosh 12 inches?
  - Easy to use if input audio channel is available
  - Difficult to process
- Complex Structured Language à la SQL
  - For expert users only, not suited for LBS
- Keywords driven
  - Buy, laptop, Apple, Powerbook, G4, screen-size = 12”
  - Relatively easy to use, but still needs complements
  - Relatively easy to process
- Menu driven (à la Ipod)
  - Buy -> computer -> laptop -> brand -> Apple -> Type -> Powerbook -> G4 -> 12”
  - Easy to use, easy to process

Query Formulation with Tokens

- *Must be simple, as few words as possible*
- Query: <**What, Where, When, What Else**>
  - < “MacIntosh 12” laptop, Zürich, tomorrow, version=English >
- Open vocabulary, avoids limiting the concept space.
  Entails the use of linguistic techniques, e.g.
  - Tokenization:
    cellphone=> <cell, phone> hands-free_cellphone => <hands-free, cellphone>
  - Lemmatization: **travel, traveling, traveled => travel jobs => job**
  - Elimination: **a, the, by, type of**

Query Formulation: Examples

- What:
  - A Chinese restaurant, a cash dispenser
  - A place selling stamps
  - A taxi
  - Am I moving North?
- Where:
  - The nearest Chinese restaurant
  - A pizza delivery service which could deliver a pizza at my hotel
  - A bus going downtown (from here, or from the Plaza Hotel)
- When:
  - The nearest Chinese restaurant still serving lunch at 3pm
  - A fine-arts museum open this afternoon
- What else: additional user preferences:
  - The nearest *expensive* Chinese restaurant

Understanding the What

- **==> linguistics + ontologies + terminology + context**
- What: "Chinese restaurant"
  - English Grammar: <adjective, noun> --- Chinese: adjective, restaurant: noun
  - Search for "restaurant" in the service module:
    - ok: If the concept is context-dependent, check what the current context is to identify the correct interpretation: Set the query as Q0: "restaurant"
    - if no restaurant in the service module, search for synonyms in the terminology
  - Search for "Chinese" within the description of restaurants
    - if Chinese appears as a value for enumerated attribute typeOfCuisine, add the predicate "typeOfCuisine = "Chinese"
    - Q1: "restaurant" AND "typeOfCuisine = "Chinese"
    - otherwise
  - Search for meaning of Chinese: pertaining to China / person from China / …
  - Select meaning "pertaining to China" as it suits the role of an adjective
  - "pertaining to China" applies either to the cuisine being served or the the owner of the restaurant
    - discard owner as normally this is not an attribute used to select restaurants
    - if there is an attribute typeOfCuisine, add the predicate "typeOfCuisine = "Chinese"
    - if Chinese doesn't produce results, try with nearby concepts (e.g. Vietnamese) or more generic concepts (e.g. Asian)

Understanding the What

- A place selling stamps
  - Selling: action, related to shops / shopping
  - Stamps: object to be sold
  - Stamps are sold by post offices only (contextual knowledge) -> place = post office
  - Query: reformulated as <post office>
- A taxi
  - Taxi: service, offered by taxi companies, contact by telephone
- Am I moving North?
  - Boolean query: yes - no
  - North: direction
  - Moving: action
  - Moving North: going in North direction: user movement leading North

Query Answering Steps

- Reformulate the user input (what, where, when, what else) as a conjunctive query: set of predicates defining the result:
  - Q: service = restaurant AND typeOfCuisine = Chinese AND location = nearest(currentUserLocation) AND priceRange = expensive
- Reformulate the query by adding/modifying predicates to take into account the user profile
  - e.g. user profile has preference for cosy restaurants
  - Q: Q U atmosphere = cosy
- Reformulate the query by adding/modifying predicates to take into account the context
  - if weather = sunny AND temperature = warm AND user-preference = outdoor
  - Q: Q AND sitting ⊇ outdoor
- Check preconditions and possibly add more predicates

Using pre-conditions

- Precedence: If the precondition for using a service is that another service must have been used before, look into the interaction history to check the precondition
  - --> need to maintain an interaction history
- Filtering: If the precondition limits the use of a service to a certain category of people, check if the querying user belongs to this category
  - the qualifying category is defined, for each type of service, by a set of predicates on the user profile
  - --> relevance links between service description and user description
- Dependence: If the precondition limits the use of a service to queries issues in a certain context, check if the current context allows for using the service
  - the qualifying contexts are defined, for each type of service, by a set of predicates on the context data
  - --> relevance links between service description and context description

Conclusion

- We are used to
  personalized and context-dependent information management. We do it routinely.
- IT has still a long way to go to do the same
- The goal is worth the effort
  - In particular in location-based services, intended to serve individual persons.