Context Awareness in Mobile Systems

CSE 162 – Mobile Computing

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Recap: What contexts can the mobile devices learn?

- Activities
- Locations

Many novel applications can be designed based on context awareness

What are contexts

- A context represents the state or situation in the environment of a system that affects that system's (application specific) behaviour
- There are many definitions of context
- There are several dimensions or properties to characterise contexts
- There are many definitions of how to make systems aware of changes in their context: context awareness
- Context-awareness is considered to be one of the fundamental properties of UbiComp systems and is a key property of smart environments.

Types of Contexts, a systematic view

- Physical Contexts
  - What
  - Where
  - When

- Computing System Contexts
  - How

- User Context
  - Who

Physical Contexts: What, Where, and When

- Physical environment or phenomena
  - Temperature, light intensity, or chemical
- Location
  - Absolute or logical locations
- Time
  - Absolute or logical time

System Context

- System Awareness
  - how any context is created and adapted over an Information and Computing infrastructure
  - E.g., Wireless connectivity
  - Charging status

User Context

- Personal Context
  - **Preference.** E.g., a referee at a sports activity may prefer to blow the whistle for minor versus major sports offences.
  - **Identity.** E.g., owner vs guest
  - **Activity and Task.** E.g., running vs standing

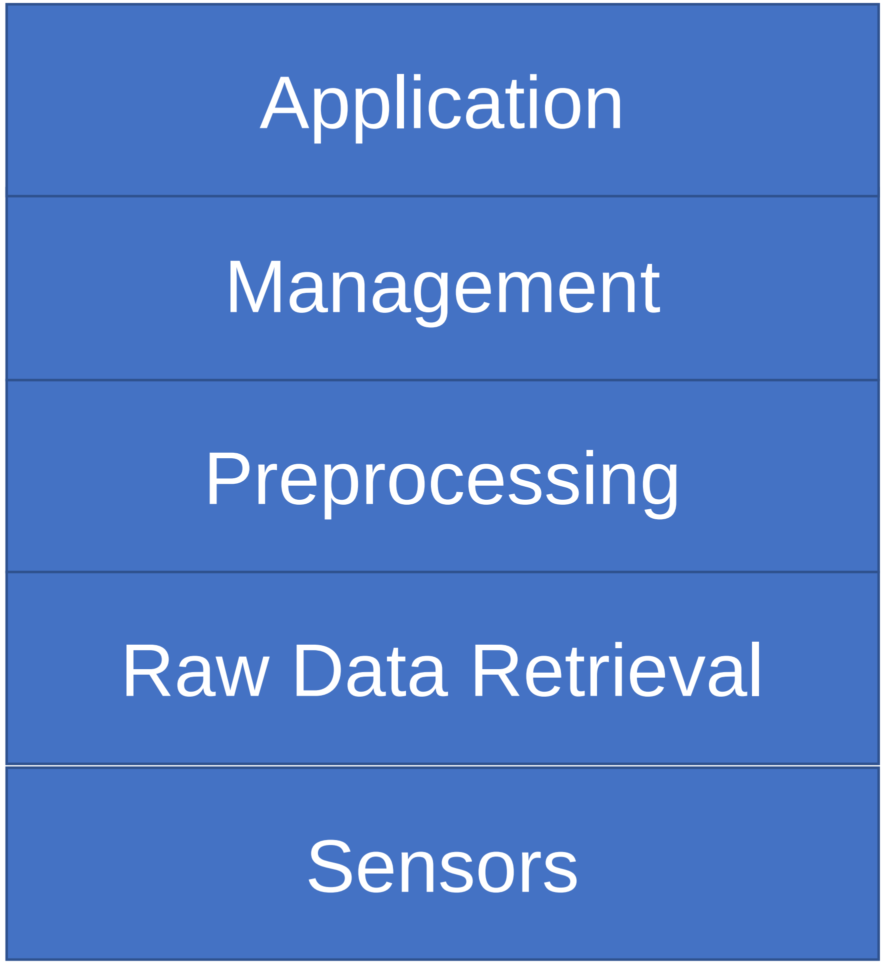
- Social Context
  - how the actions of someone may affect others
  - E.g., who blows the whistle? The referee, policeman, or spectator?

Static versus Dynamic CA

- Static context
  - describes those aspects of a pervasive system that are invariant
  - E.g., date of birth, User preference, home location, etc

- Dynamic context:
  - Information that changes change frequently
  - E.g., user activities, current locations, etc

Context Aware System Architecture



First Layer: Sensors

- Both sensing hardware and other data source that provide usable context information
- Three groups
  - Physical sensors
  - Virtual sensors: source context data from software applications or services.
  - Logical sensors: combine physical and virtual sensors with various other sources in order to solve higher tasks

Context Determination

- Context determination: acquisition, accuracy particularly of user context can be complex
- Active versus passive context acquisition
- Single shot (static) versus dynamic acquisition
- Heterogeneous context representation (syntax) and semantics, interoperability
- Context distribution: Local context producer but remote context consumer

Context Determination Approaches

- Combine several low-level sensor inputs

- Query user profile or model
  - abstraction that characterises the user, preferences the user expresses,

- Ask users to define their own context.

- Observing user interaction

Second Layer: Retrieval of Raw Sensor Data

- Software components which make low-level details of hardware access transparent by providing more abstract methods
  - E.g., getPosition()

Third Layer: Processing

- Interpreting contextual information
  - E.g., convert GPS position into the name of the room the person.
- Aggregate raw sensor data from multiple sources to obtain valuable data
  - E.g., Use temperature, light, noise level, and location to determine whether indoor or outdoor.

Fourth Layer: Management

- Organizes the gathered data and offers them via a public interface to the client.
  - Discovery: enable context sources, stores and users to be registered and discovered.
  - Storage
  - Sharing. Share environment and goal contexts so that they can be distributed and accessed.
  - Access control: protects the privacy

Fifth Layer: Application

- The actual reaction on different events and context-instances is implemented here.

Context Adaptation

What is it?

- A context adaptive system typically enables the user to maintain a certain application while roaming between different contexts.
  - E.g., wireless access technologies, locations, devices and even simultaneously executing everyday tasks like meetings, driving a car etc
- Example: a ubiquitous navigation system would offer navigation support in the situations *at home*, *indoor*, *outdoor*, and *in car*.

Context Adaptation Benefits

- Reduces information overload on users
- Lessen cognitive load on users
- Filter information to fit a mobile device's limited and physically moving display,
- Disabled people
- Improve Regulation & Control

Context Adaptation: Passive vs Active

- Passive context adaptation system
  - Context is presented to users
  - System is not active in terms of adapting
- Active context-adaptation system
  - Adaptation to context performed by the system, not human users.
- Hybrid context adaptive system
  - Human user guides or corrects the automatic adaptation

Context Adaptation Models

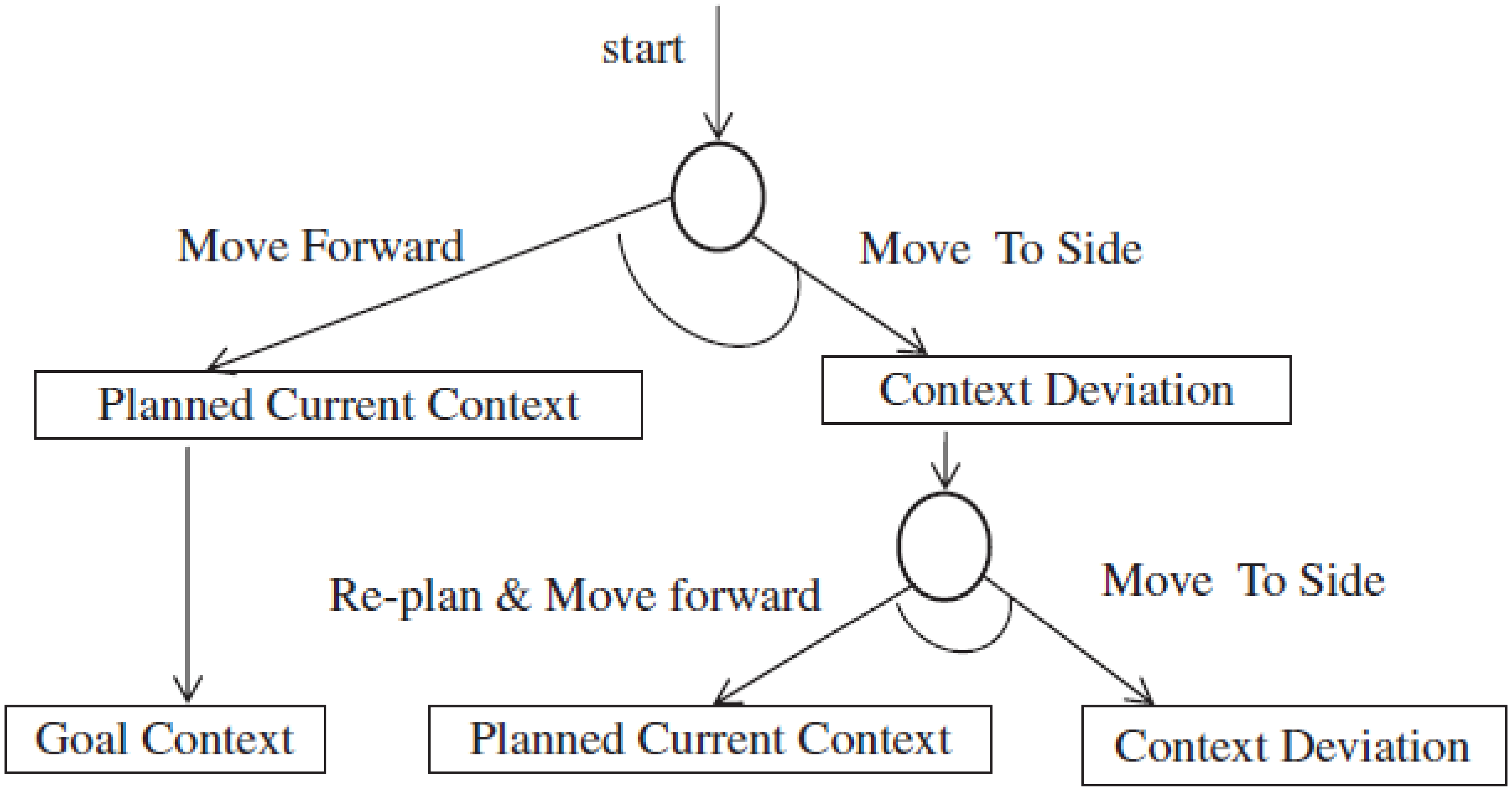
Event-based Models

- Context-awareness links context producer to a context-consumer or context-adapter

Goal-based Models

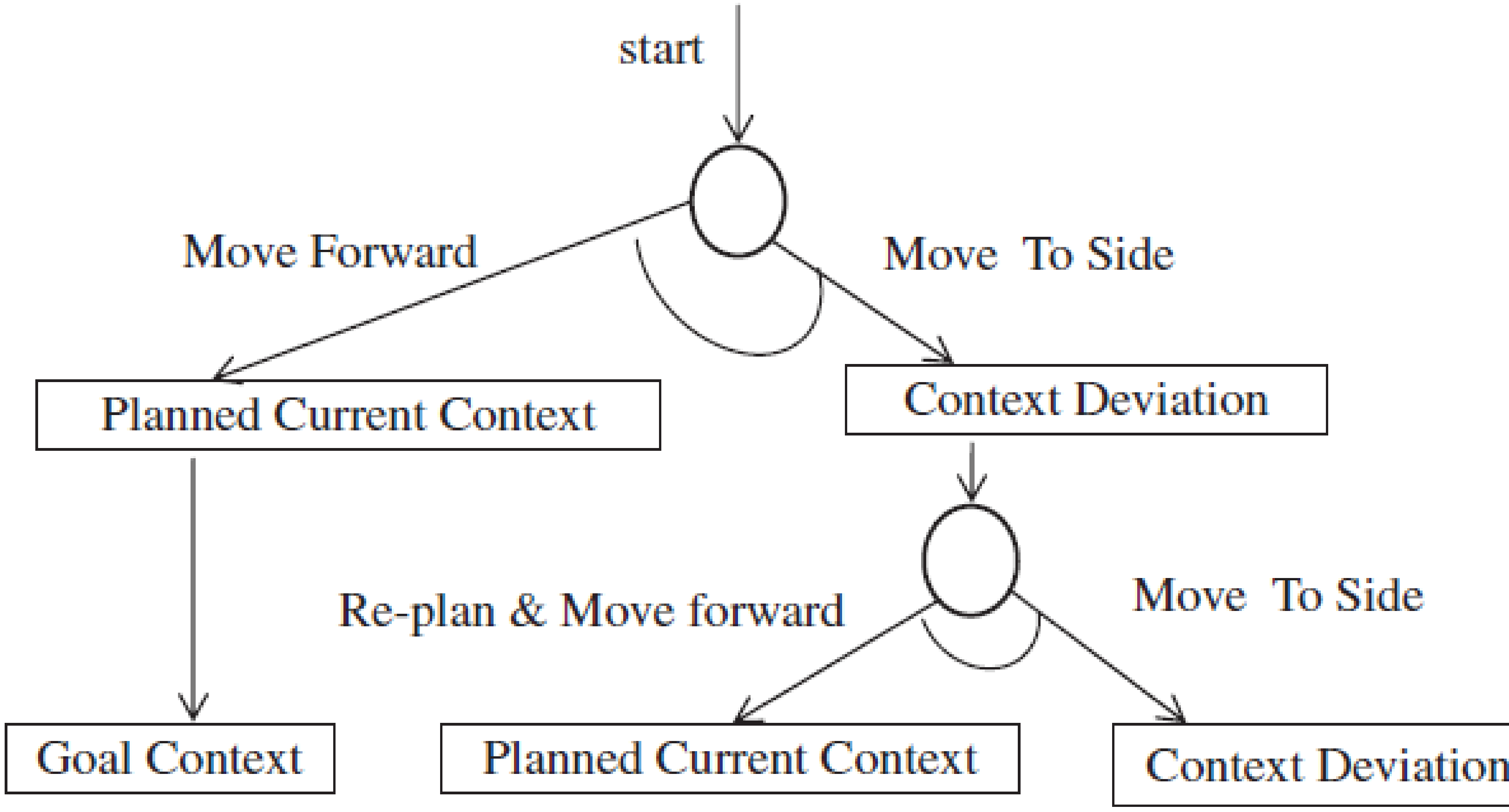
- Use the user goal to limit the set of current contexts which are useful
- **Relation of current context to goal context is fundamental**

A Conditional Planning Model of Context-Awareness



Example: Goal-based context adaptation model

- Goal context: destination location
- Current context: current location
- Context path: a planned navigation path
- Constraints: not to deviate too far



Challenges in Modeling Contexts

- Challenge: context information exhibits a range of temporal characteristics
- The dynamic context information can be highly variable
  - E.g., locations, activities
- May be interested in not only the current state of the context, but the past and future states.
  - E.g., calendar app that uses future schedules
- Solution
  - indirect means for context acquisition, such as through sensors.

- Challenge: Contexts may be incorrectly, incompletely, imprecisely defined, determined or predicted

- Cause
  - Delays
  - Implicit observations of user contexts may be incorrect, incomplete or imprecise
  - User contexts modelling from too little input data, over too small a time period

- Solution
  - Use context composition to improve context accuracy
  - More accurate contexts require time to tune. Use machine learning, and simulation to improve the determination and prediction of user context over time

- Challenge: Multiple alternative context representations
    - There is usually a significant gap between sensor output and the level of information that is useful to applications
    - E.g., raw coordinates are obtained from sensors, whereas an application might be interested in the identity of the building or room a user is in.

- Solution:
    - Support multiple representations of context be able to mediate between them

- Challenge: Context information is highly interrelated.
  - Both evident and less obvious relationships between people, device, and communication
  - E.g., ownership of devices can be indicated by the proximity between users and their devices. Current location can indicated activities

- Solution
  - Partial contexts may need to reason about to predict the part that isn’t readily accessible

- Challenge: Device resource constraints

- Cause
  - Context sources such as sensors are highly distributed, mass produced and embedded in cheap low cost, low resource mobile systems

- Solution
  - Consider the trade-off in the expressivity of context messaging against the resources needed to handle such messages

- Challenge: context-awareness may generate huge volumes of data

- Cause
  - Large complex environments may be studied, many sensors may be used
  - Focus is on archiving context data rather than on applying the context

- Solution
  - Filter context information before storing
  - Use appropriate search and archiving techniques for storage
  - Use data mining techniques to analyse data

- Challenge: Privacy

- Cause
  - Contexts are often naturally linked to humans to be of use

- Solution
  - Information Security is needed to protect context information

- Challenge: Awareness of context signals and shifts can overload users or distract users

- Cause
  - Many systems have the autonomy and status awareness, and they have the urge to self-maintain and upgrade
  - If context-shifts cause automatic control, use can be disrupted

- Solution
  - Ensure context shifts if automated occur safely and do not disrupt users