Dude, Where's My Car?
And Other Questions in Context-Awareness

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The Context Fabric:
Infrastructure Support for Context-Aware Computing

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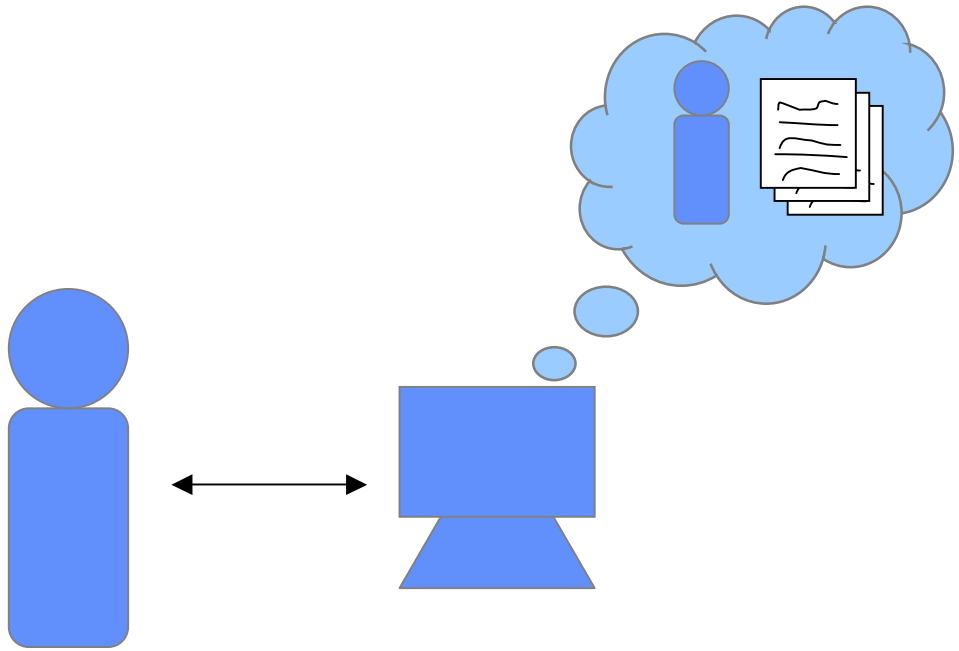
What's Context?

- Context?
  - Situated Action, Activity Theory, Distributed Cognition, Linguistics, Embodiment
- Computational view
  - Increase input channels into computer
  - Push towards implicit acquisition
  - Create better models to take advantage of input
  - Using the input + models in useful ways
- Focus is on physical world, distributed, implicitly acquired context

Motivation



We sort of know how to handle context-awareness here

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Motivation

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Motivation

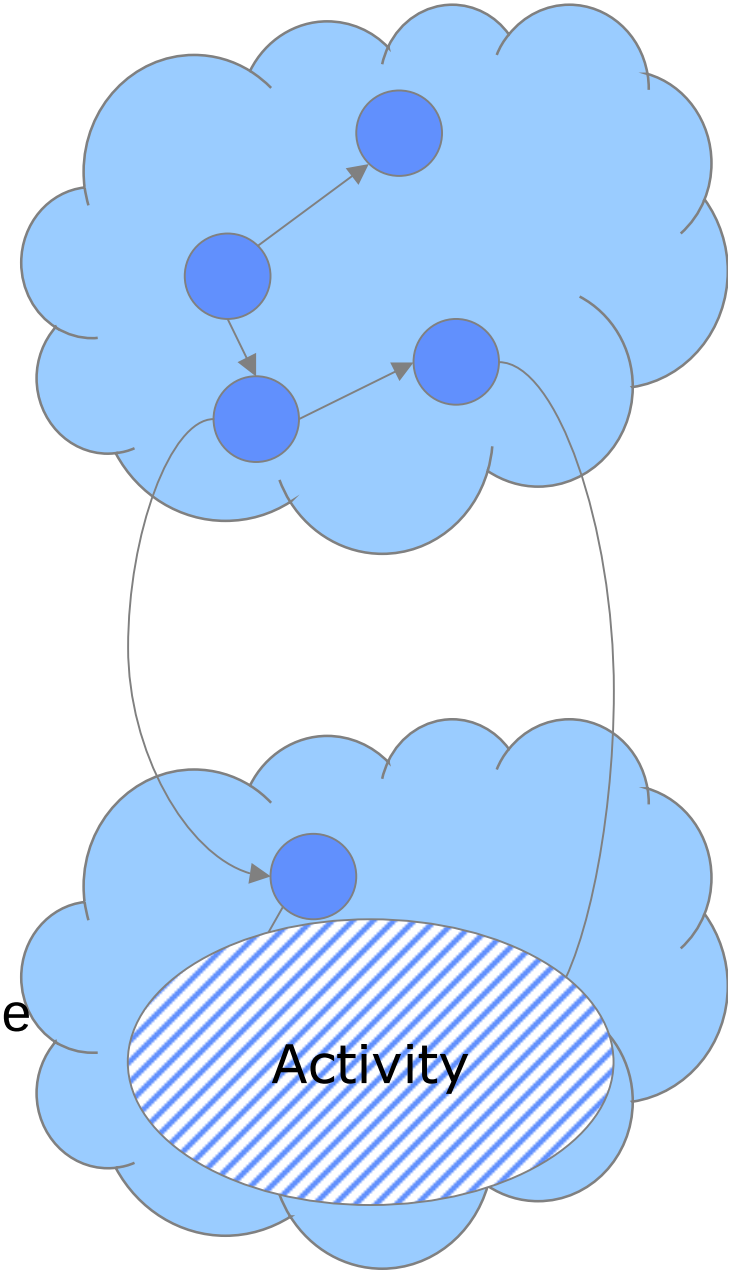
- Still really hard to build context-aware apps!
  - Same context data can come from many sources
  - Context data is highly distributed (emergent)
  - Need more expressive data models
  - These context models have not addressed security and privacy concerns
  - Difficult to program applications in an environment that is constantly changing in terms of sensors, services, and context data
- Context Toolkit
  - Operating system view – abstraction to hardware, programming it
  - Database view – how data is modeled, distributed, protected, and used

Proposed Solution

- Infrastructure approach
  - TCP / IP analogy
  - Data formats and network protocols, services out there that you can rely on being there
  - Be agnostic of sensor, CPU, OS, programming lang, network, discovery service, service platform
  - Have to be able to evolve and incrementally deploy
- Three things
  - Distributed data model of people, places, things
  - Context Specification Language (like SQL)
  - Context service as API into this all (per device)

Data Model

- Three questions:
  - How is context data represented?
  - Where does it live?
  - How is it shared?
- Semi-structured data
  - No universal ontology, situation dependant
  - Support multiple schemas simultaneously
- Multiple tuple-spaces
  - Each device has a space (no servers)
  - CAP theorem, weak consistency
  - Local / Private data goes to your space
  - Different levels of trust for each
  - Multiple views of context
    - Mine, yours, theirs



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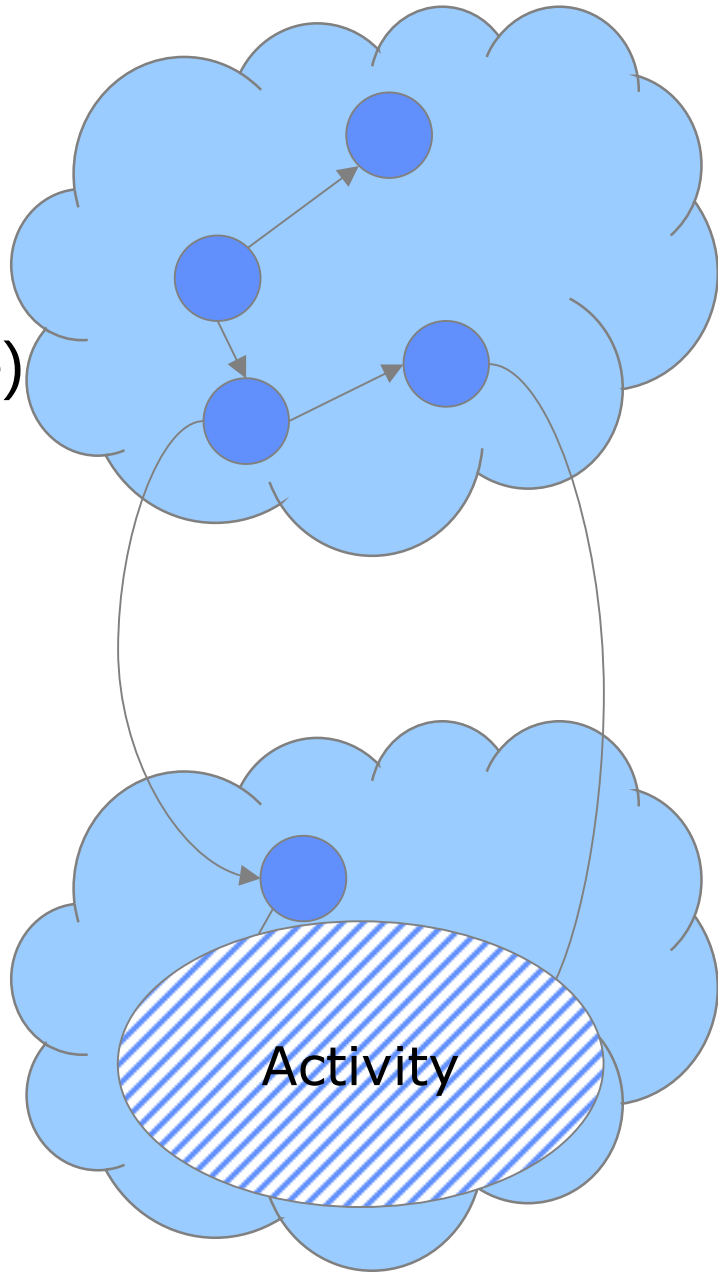
Data Model

- Entities
  - People, places, things
  - (Haven't figured out space, time)
  - Certificates, Access control, Views on data
- Attributes
  - Tons of metadata
  - Source? Trusted? Age? Delta? Precision? Accuracy?
- Relationships
- Aggregates
  - Indexes, Active Maps, Action, Workgroup, Histories



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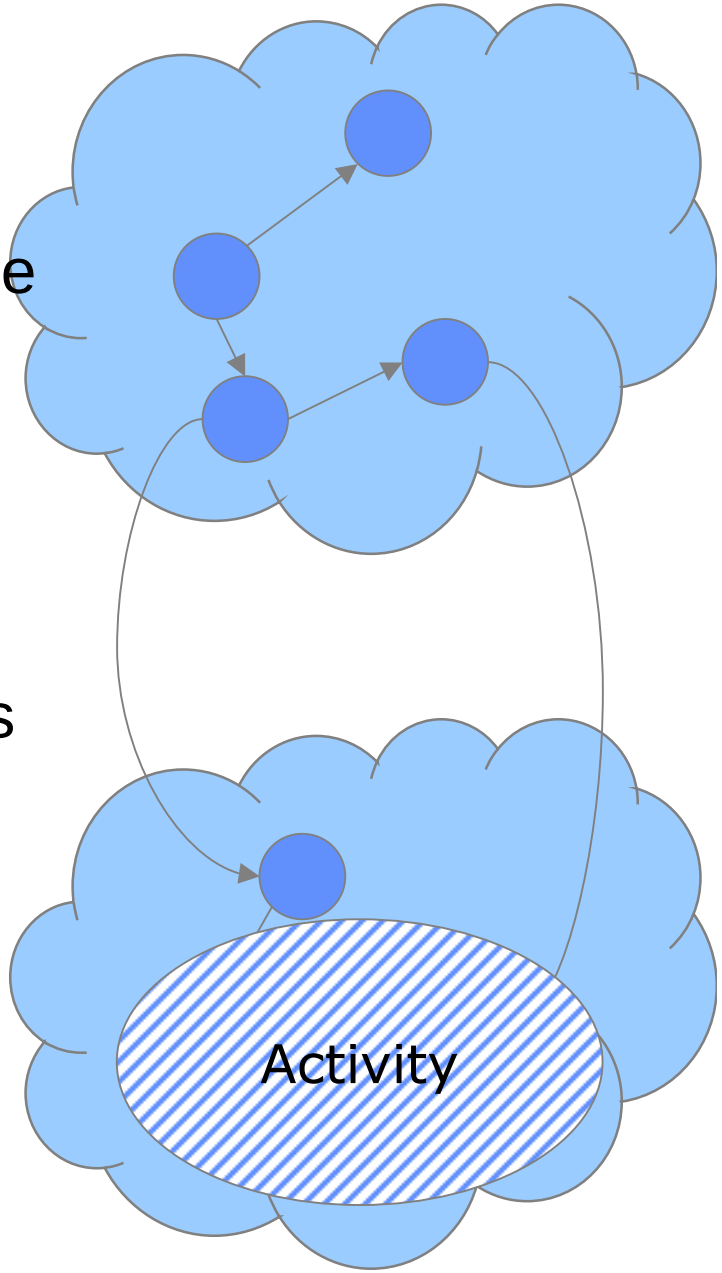
Data Model

- Advantages
  - Separates acquisition, model, usage
  - More resilient to failure
  - Multiple schemas provide flexibility
  - Context data lives separately from process, application, device
  - Templates for basic privacy policies
    - Family, friends, co-workers, strangers



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Context Specification Lang

- Problem: Difficult to coordinate data and services to get the right context data procedurally
- Idea: Declaratively specify what you need
- Query
  - "What are the nearby movie theaters?"
  - “How many people are in the room right now?”
- Events
  - “Notify me every time a person enters the room.”
  - (Like programming the physical world)
- Still vague, still in progress
  - Don't want to solve Natural Language Problem!
  - Basic templates for common types of queries
    - "What are the nearest X?" "Where is Y?"

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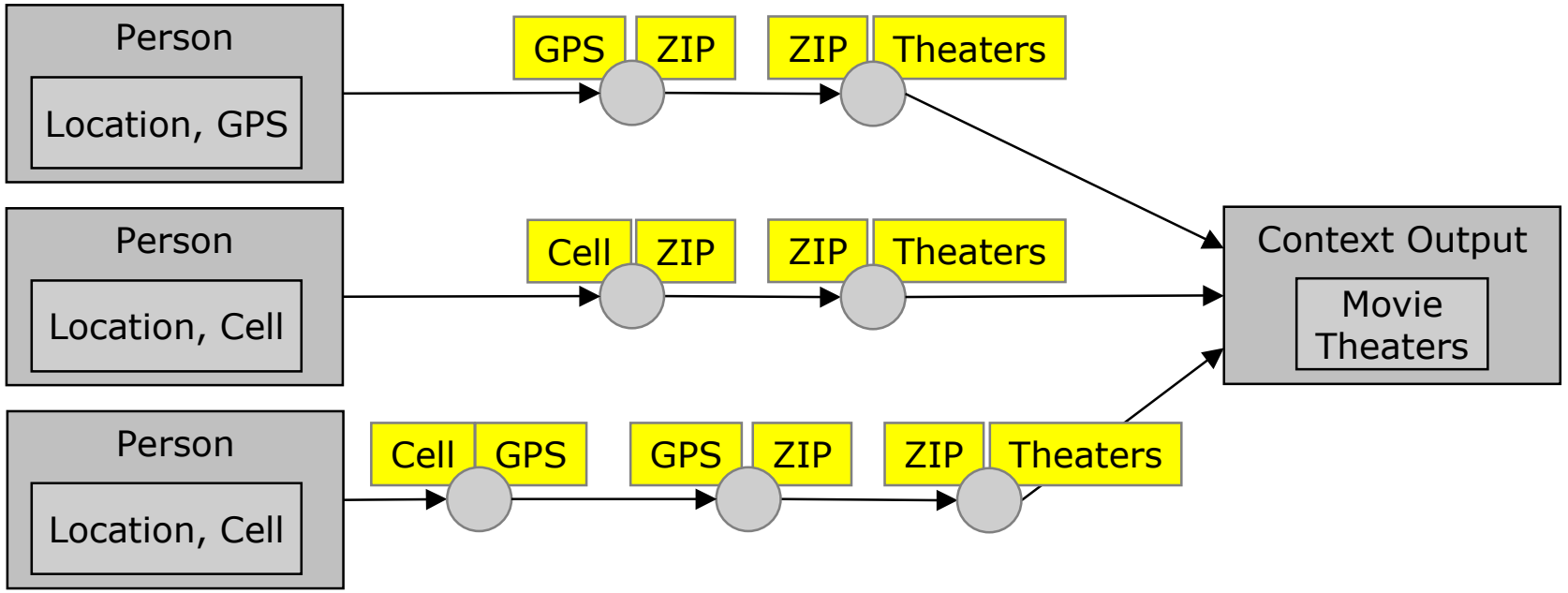
Context Service

What are the nearby movie theaters?



- Interpreters
- Data type transducers
- Fusers
- Filters
- Introspection: What's going on?

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Speakeasy:
Supporting the Ubiquitous Computing User Experience

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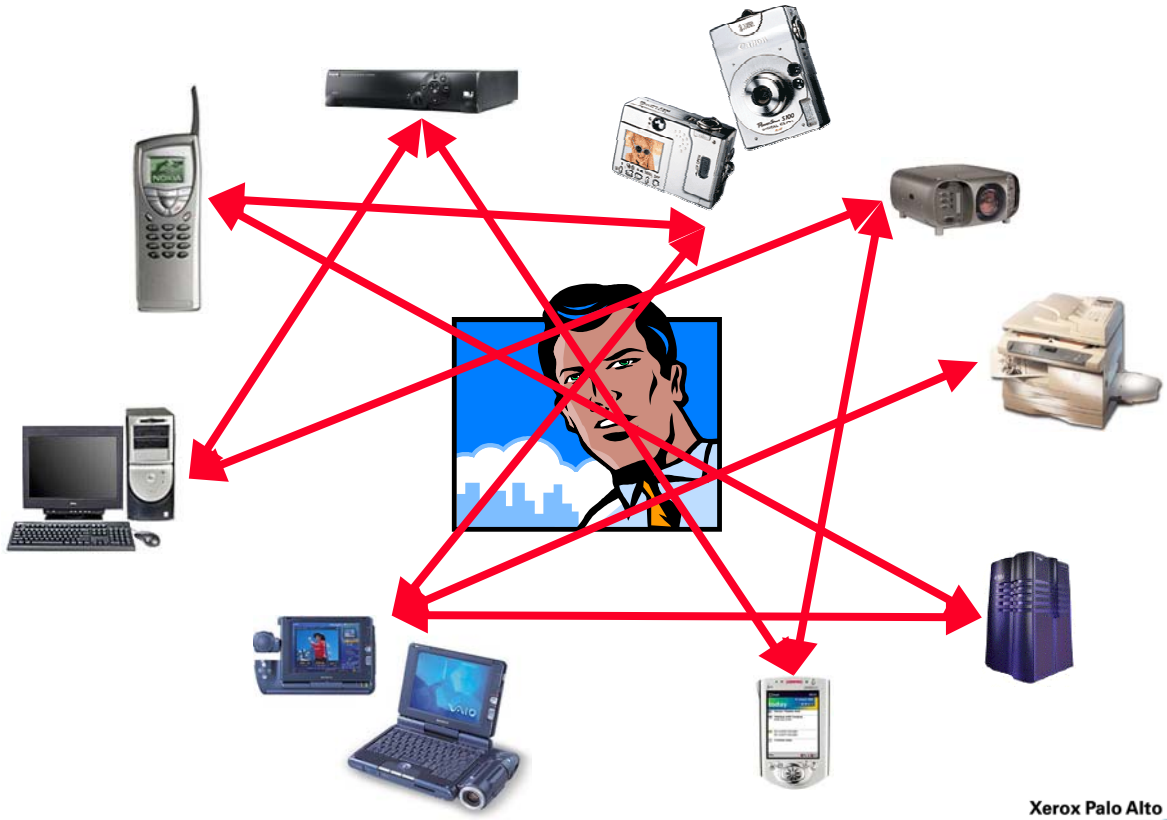
Motivation

The era of ubiquitous computing is upon us

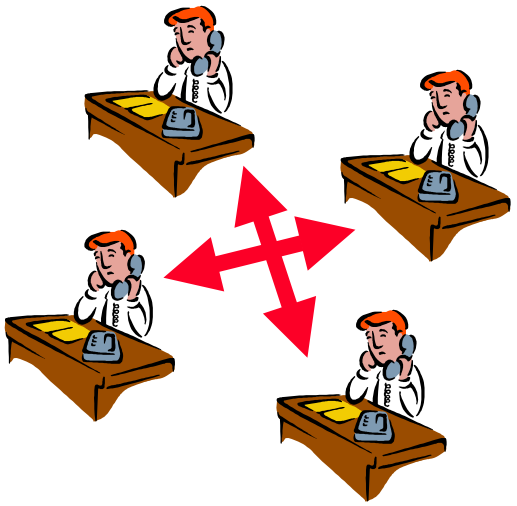
– many devices per person, becoming interconnected



The Speakeasy Vision

Enable Network Effects

– analogous to phone, fax, web…



Radical Interoperability

– what if anything can talk to anything?
– every new device or service adds value

Deal with Complexity

– support users' sensemaking
– what can I do in this world?
– what the heck is going on?

Interoperability

No need to write specifically for a new component

- Interact with components you've never heard of
  - Interact with *types* of components you've never heard of

Our approach: mobile code + standard interfaces

- (+ discovery + shared network)

Identify the *minimal set of interfaces.* So far…

- Data transfer & transformation
- Status & notification
- …
- Context
- User interface

User Experience

Context

- Modeled as People, Places, Things (Components)
- People
  - What components have I used before?
  - What components belong to me?
- Places
  - What components are in this place?
- Components
  - Where am I?
  - What can I do?
  - How have other people used me?

Key Idea

- Provide key information to people, not infer