Architecture Patterns for Mobile Systems in Resource-Constrained Environments

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Motivation

First responders, soldiers and other front-line personnel operate in resource-constrained environments characterized by

- intermittent or no connectivity to traditional infrastructure;
- a fast-paced, highly-fluid and unpredictable environment;
- the potential of large amounts of raw data and information;
- resource challenges (i.e. power, computing, etc.); and
- periods of very high stress and cognitive load

Mobile systems in these environments must

- Provide situational awareness and data analysis even if disconnected from the enterprise
- Reduce cognitive load and complexity, particularly in situations of high stress
- Increase computing power, data access, and survivability of computing capabilities while reducing demands on person-carried resources

Architecture Patterns

In software engineering, a pattern represents a proven solution to a recurring design problem

- Gamma et al were the first to develop design patterns for object-oriented systems
- Buschmann et al were the first to present architecture patterns for large-scale applications that could be composed to promote certain system qualities

Architecture patterns have been developed for specific types of applications or domains, such as

- concurrent and networked systems
- enterprise applications
- distributed systems
- resource management

This presentation focuses on architecture patterns for mobile systems that address the challenges of resource-constrained environments

Data Source Integration Pattern — Problem

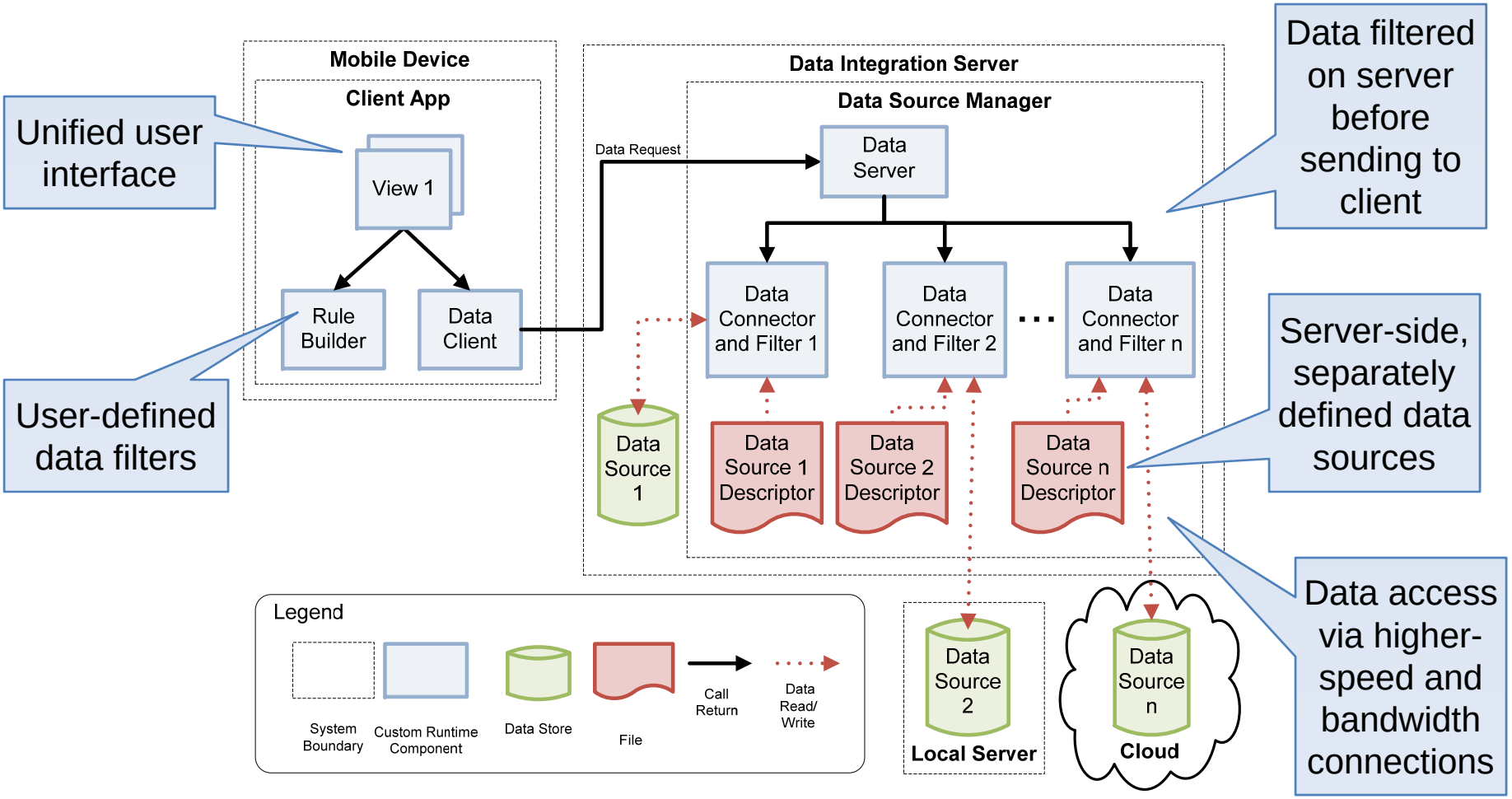
Motivation

- Situational awareness (SA) applications in the field must support the rapid creation of mashups from multiple sources that might not be known in advance

Problem

- Rapid incorporation of new data sources
- Minimized information overload
- User control of data sources, data volume and visualization
- Simple use

Data Source Integration Pattern — Solution



Group Context Awareness Pattern — Problem

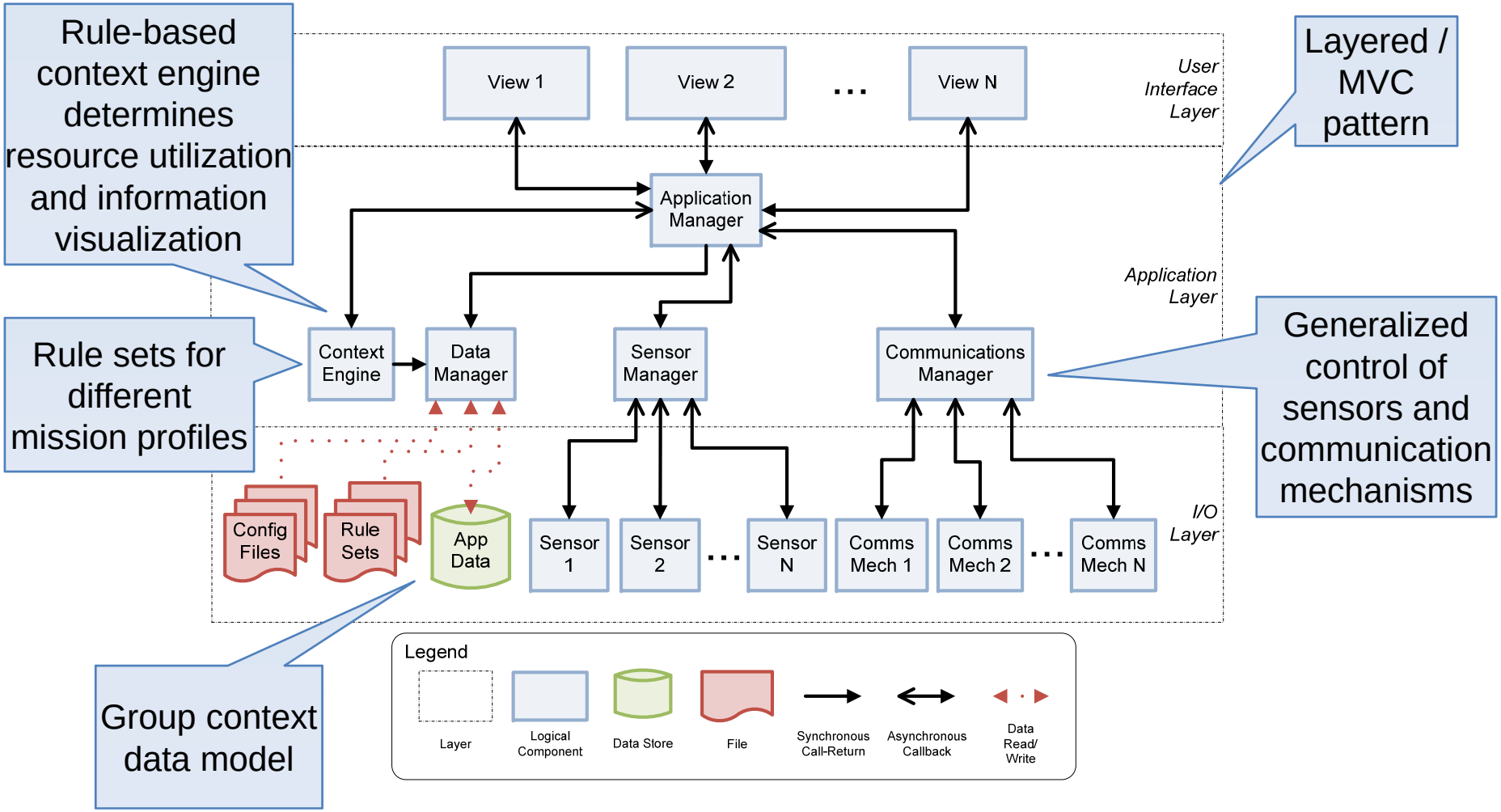
Motivation

- Individuals at the edge operate cooperatively in teams
- Crucial that every team member receives the right information at the right time in order to ensure their safety and effective actions

Problem

- Flexible enough to create, understand, and react to unpredictable events that were never imagined during planning
- Resilient to intermittent communication and opportunistic in using communication access as it sporadically becomes available
- Capable of managing mobile resources as efficiently as possible to maximize the availability of the system
- Address cognitive load by providing mechanisms for supporting the information needs of the group while requiring minimal attention and interaction

Group Context Awareness Pattern — Solution



Cloudlet-Based Cyber-Foraging Pattern — Problem

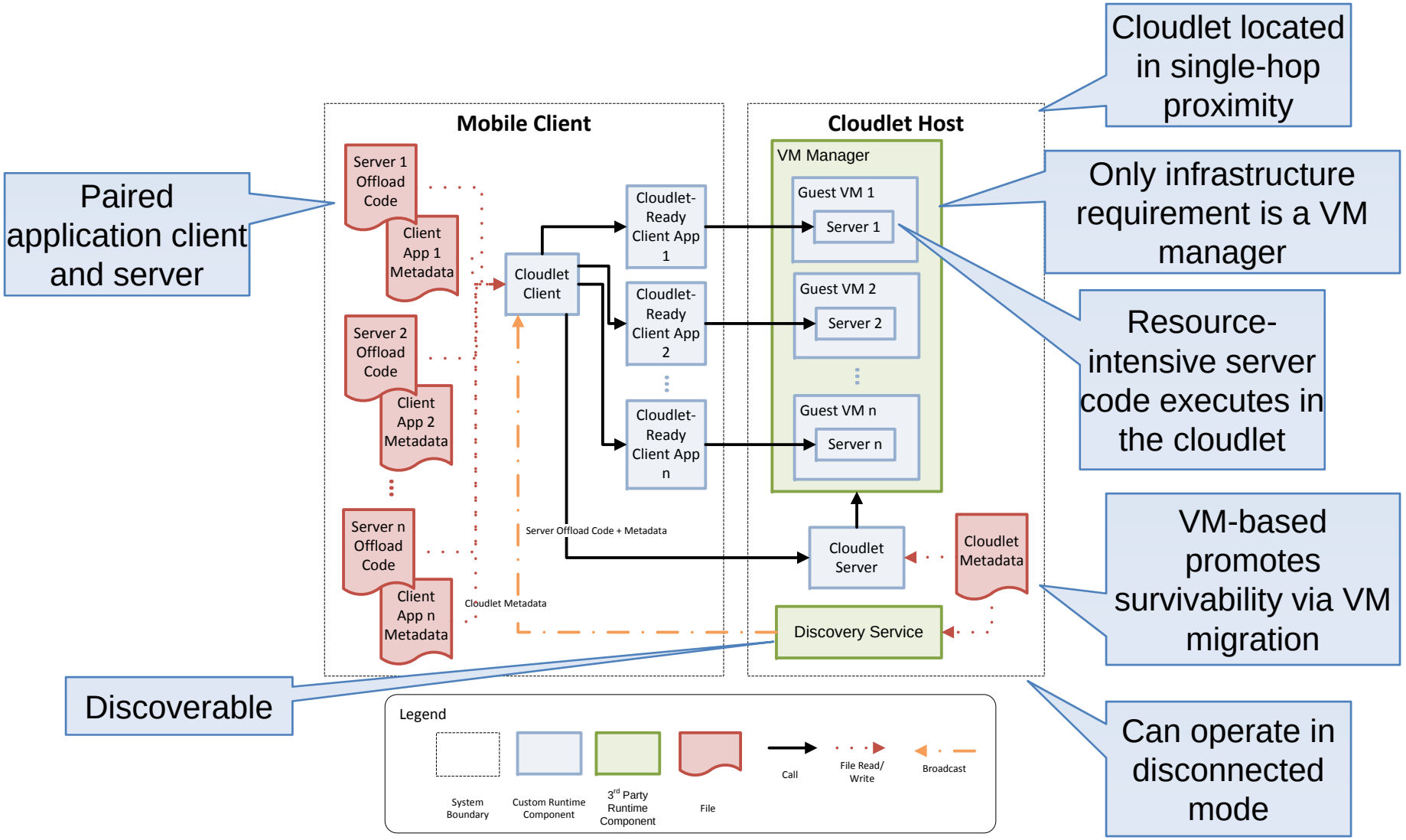
Motivation

- Applications that are useful in resource-constrained, mission execution environments (e.g., face recognition, speech recognition)
  - require great amounts of battery and computing power
  - might not be able to execute on the mobile device due to the complexity of the code

Problem

- Cyber foraging is a technique to enable resource-poor, mobile devices to leverage external computing power by offloading code to surrogate
- Most existing cyber-foraging solutions
  - Assume connectivity to the cloud
  - Tightly couple offloaded applications to the infrastructure

Cloudlet-Based Cyber-Foraging Pattern — Solution



Current and Future Work

We have implemented these architecture patterns using current technologies to demonstrate their technical feasibility

Implementations have been taken to field experiments and operational exercises

Currently working on the combination of these patterns to support context-aware, rapidly deployed SA solutions

- Data Integration Server is rapidly deployed from a mobile device onto a cloudlet using Cloudlet-Based Cyber-Foraging
- Group-Context-Awareness is used to tailor the information that is retrieved and visualized on each mobile device

We are also working on additional architecture patterns to account for dynamic environments

Conclusions

We presented a set of architecture patterns for mobile systems in resource-constrained environments to support personnel operating in edge environments

Architecture patterns are driven by flexibility, resource efficiency, and usability which are key quality attributes for systems at the tactical edge

Goal of these patterns is to enable system architects to instantiate them using a variety of technologies that can meet functional and quality requirements

Contact Information

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