A model for distributed adaptation applied to replicated data management

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Issues

- Execution environment
  - Heterogeneity of hardware, network, software
  - Variation of execution conditions
    (connections/disconnections, failure…)

- Various and changing needs of users

  Need for context management and dynamic adaptation
Issues

- Complex distributed applications
  - Many entities with different adaptation needs
- Single adaptation system
  - Complexity, Scalability, Adaptation overhead, Autonomy…

Need for distributed adaptation

- Long life time → non envisaged situations

Need for adaptable adaptation system
Goals

- Illustrative application: data replication
- Our approach
- Case study: adaptation of replication
- Conclusion and future work
Goals

- To design a software architecture to ensure the dynamic self-adaptation of distributed applications
  - Granularity of entities to adapt (several applications, component…)
  - Model for dynamic adaptation
    - Adaptation functionalities
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Illustrative application

- Distributed data replication system
  - Traditional technique to improve the quality of data sharing (performance, availability…)

- Need for dynamic distributed adaptation
  - Application has many algorithms
  - Replication services are distributed
  - Variability of execution context
    - Storage and treatment capacities of devices, bandwidth…
  - Varieties of user requirement
    - Latency of access, consistency level…
Illustrative application

- Replication of medical data among different health practitioners

Diagram: Diagram shows a network connecting Hospital H1, Doctor’s office, Patient’s residence, and a Mobile health agent.
Limits of existing works

- Framework for replicated data management not complete and/or not modular
  - e.g. RS2.7 is focused in consistency protocol [DRA03]

- Static mode of replication adaptation
  - e.g. rules to change the consistency protocol are embedded in the model [YU02]
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  - Framework for distributed adaptation system
  - Cooperation of adaptation systems
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Our approach

- Distributed software system is a set of interacting entities
  - An entity is a component which can be composite and distributed

- Component-based framework for adaptation
  - Adaptation system is a set of components
Our approach

Adaptation architecture model
used to derive adaptation variants

Application architecture model
used to derive application variants

Distributed adaptation system
Adapts

Distributed software system

Adaptable system

monitors

Preferred quality
provided quality

User's needs
Network QoS
Computing resources
Position

User
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Model for replication system

- **Placement**
  - Creates replicas and place them on sites
  - Deletes replicas

- **Selection**
  - Selects replicas to execute operations (read/write)

- **Updates propagation**
  - Ensures the functions contributing to the update of the replicas

- **Access**
  - Manages the local access (insert/delete and read/write)
Deriving a replication system

- Make a choice in points of variation
- Types of points of variation
  - Internal variation: define variables that determine program behavior
  - Behavioural variation: choose algorithms
  - Structural variation: select components that compose an replication system and bind them
  - Distribution variation: choose components placement over distributed nodes
Example of derivation

Mobile health agents

Hospital H1

Hospital H2

Patient’s residence

Doctor’s office

Pla Placement

Acc Access

Sel Selection

Upd Updates

Propagation

Sel9

Sel1

Upd1

Acc1

Pla1

Sel3

Upd3

Acc3

Pla3

Sel6

Upd5

Acc6

Sel6

Upd2

Acc2

Pla2

Sel8

Upd4

Acc4

Pla8

Sel8

Upd3

Acc8
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Model for adaptation system

- **Context management**
  - Monitors and analyzes the context to make an entity context-aware

- **Decision**
  - Chooses the strategy to adapt an entity according to context

- **Planning**
  - Determines the adaptation plan which orders the actions that will make the entity achieve the strategy

- **Execution**
  - Executes the planned actions
  
  ...
Deriving an adaptation system

- Make a choice in points of variation

- Types of points of variation
  - Internal variation: define variables that determine program behavior
  - Behavioural variation: choose algorithms
  - Specialization variation: define adaptation policy, adaptation guide…
  - Structural variation: select components that compose an adaptation system and bind them
  - Distribution variation: choose components placement over distributed nodes
Example of derivation

Mobile health agents

Doctor's office

Hospital H1

Hospital H2

Patient's residence

Sel9

Sel1

Pla1

Upd1

Acc1

Sel2

Pla2

Upd2

Acc2

Sel3

Pla3

Upd3

Acc3

Sel4

Pla4

Upd4

Acc4

Sel5

Pla5

Upd5

Acc5

Sel6

Pla6

Upd6

Acc6

Sel7

Pla7

Upd7

Acc7

Sel8

Pla8

Upd8

Acc8

Sel9

Pla9

Upd9

Acc9

Access

Updates

Propagation

Selection

Placement
Example of derivation

Network

Hospital H1

Site

Doctor's office

- Context management
- Planification
- Decision
- Execution

Pla1

Sel1

Upd1

Acc1

Sel9

Pla8

Sel8

Acc4

Acc8

C

D

P

E

C

D

P

E

P

E

D
Considered aspects when deriving

- Entities' adaptation requirements
- Evolution of adaptation system
- Flexibility
- Performance
- Scalability
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Cooperation of adaptation systems

- Entities are not aware about other entities’ requirements → shared resources
  - Placement component uses a lot of bandwidth
- Some adaptations can affect the consistency of the global system
  - Replacing the placement strategy can affect the performance of consistency protocol

Some adaptation systems must cooperate
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Case study

- Replication of medical data among different health practitioners
- Normal situation: Tele-surveillance for patient at home
  - Placement: Low replication degree, Random placement, Fixed machines
  - Selection: Random selection
  - Consistency: Weak
Case study

- Urgency situation: reduced access latency and freshness of replicas
  - Placement: High level of replication, Latency-based algorithm, Fixed and mobile machines
  - Selection: Latency-based algorithm
  - Consistency: Strong
Adaptation scenario

Hospital H1

Hospital H2

Mobile health agent

Doctor's office

Patient's residence

Bandwidth
Example of derivation

Hospital H1

Hospital H2

Patient’s residence

Mobile health agents

Doctor’s office

Upd1 → Pla1 → Sel1 → Acc1

Upd3 → Pla3 → Sel3 → Acc3

Upd4 → Pla4 → Sel4 → Acc4

Upd5 → Pla5 → Sel5 → Acc5

Upd6 → Pla6 → Sel6 → Acc6

Upd7 → Pla7 → Sel7 → Acc7

Upd8 → Pla8 → Sel8 → Acc8

Pla = Placement
Sel = Selection
Acc = Access
Upd = Updates
Prop = Propagation
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Conclusion

- Distributed replication system reveals potential benefits of distributed adaptation
- Preliminary model-driven approach for constructing an adaptation system for distributed entities

Experimentation

- Fractal/Julia
- Implementation of a preliminary prototype
- Decisions in points of variation are made manually by the adaptation designer
Future work

- General approach for construct an adaptation system for distributed entities
- Study different cooperation techniques and cooperation strategies
- Make the adaptation system adaptable
References
