Dynamic Context Management and Reference Models for Dynamic Self-Adaptation

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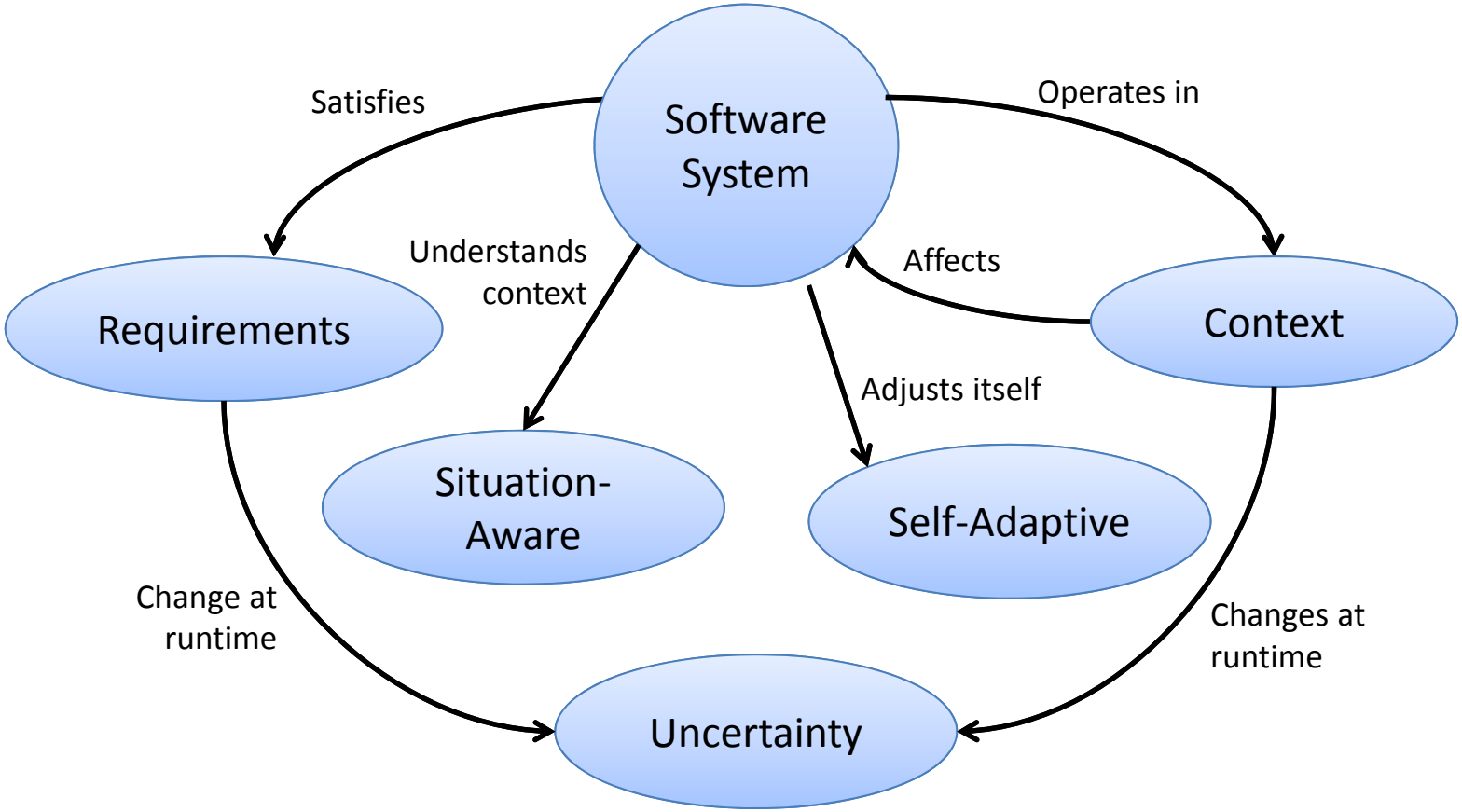
Fundamental Concepts



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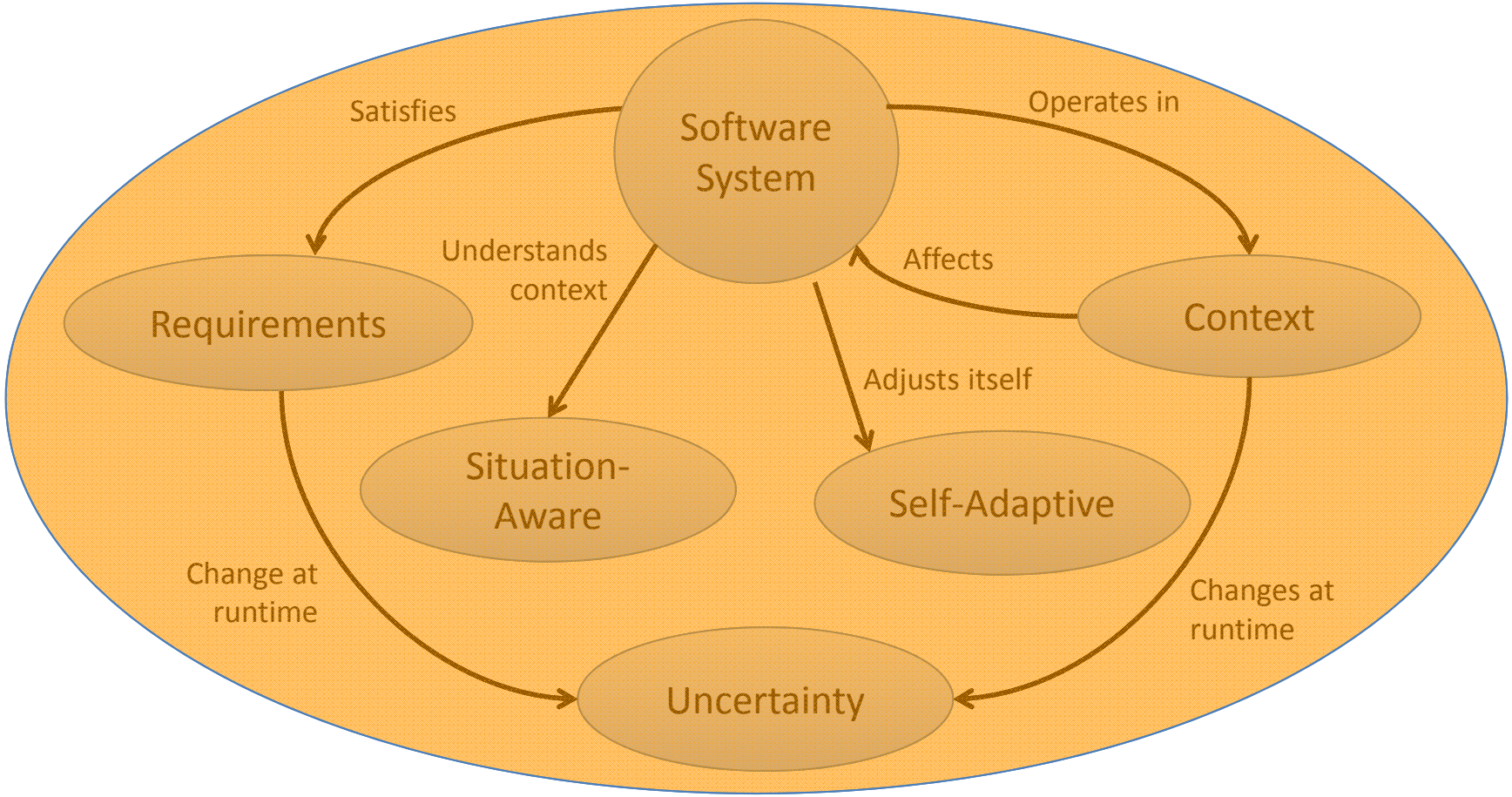

Situation-aware smart software (SASS) system

Problem Statement

To maintain the relevance of situation-awareness,
with respect to changing requirements and context situations,
to improve user QoE and **self-adaptivity**

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Selected Research Challenges

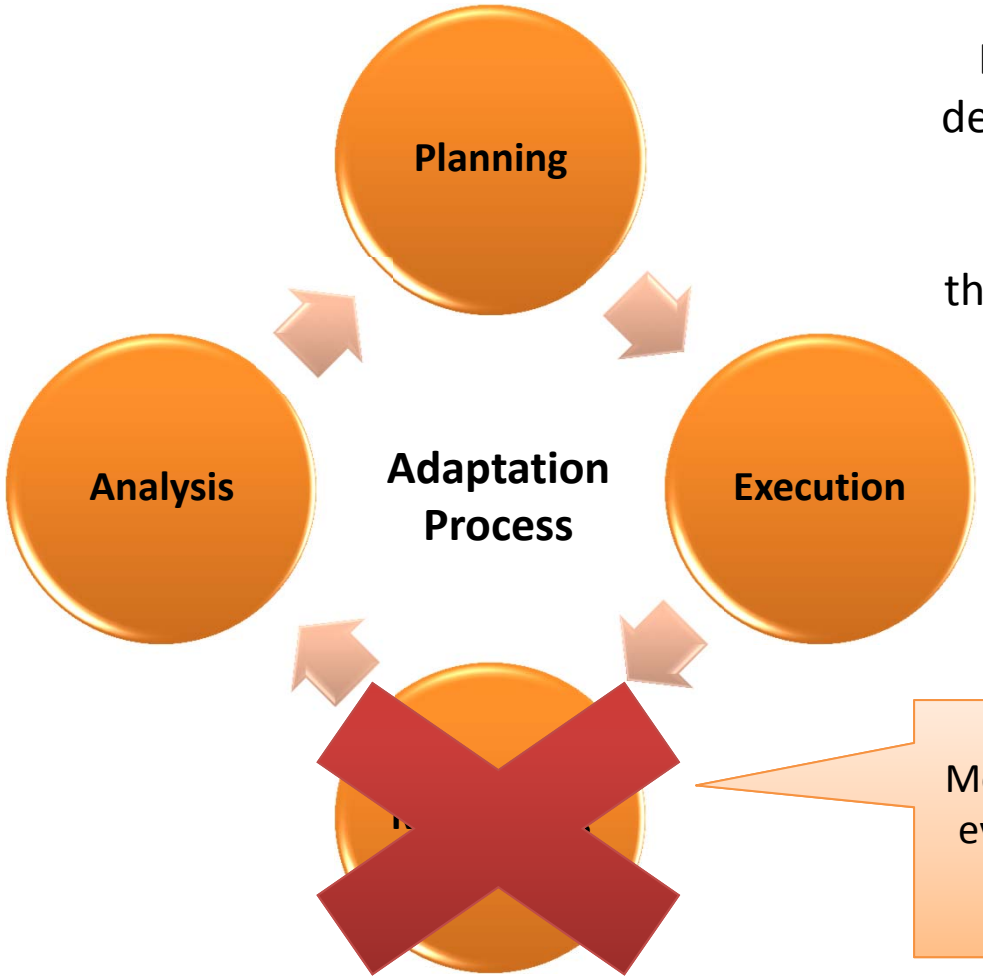
CH1: Complete specification of context is impractical at design time (uncertainty)

CH2: Context monitoring infrastructures must be self-adaptive and user-driven

CH3: The need for reference models for self-adaptation that address dynamicity at all levels

CONTRIBUTIONS ON DYNAMIC CONTEXT MANAGEMENT

Uncertainty in Self-Adaptation
Necessity of Dynamic Context Management



Effectiveness of Self-adaptation depends on dynamic capabilities of monitoring mechanisms to preserve context-awareness throughout the adaptation process

Monitoring requirements evolve over time due to uncertainty

Contributions (1): The SmarterContext Ontology and Context Spheres

Our semantic web solution to context modeling

- Modeling support for:
  - Context entities and their relationships
  - Context reasoning rules
  - Context monitoring requirements
  - Privacy policies
- Adaptable at runtime
- Fully extensible
- Empowers users as context managers

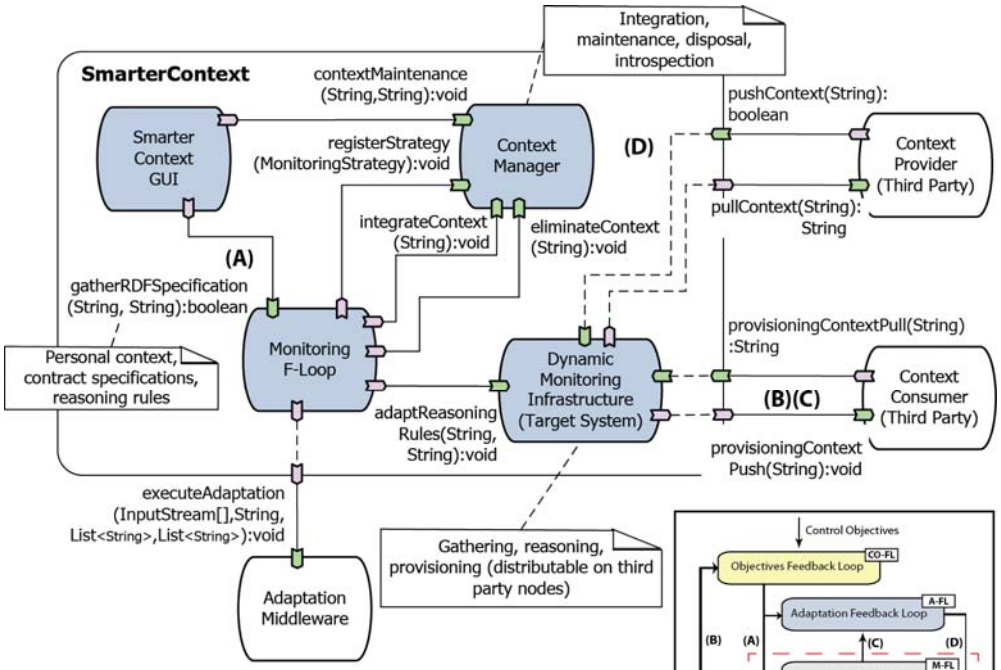
Villegas and Müller: *The SmarterContext Ontology and its Application to the Smart Internet: A Smarter Commerce Case Study*. (Springer 2013)

Contributions (2): The SmarterContext Reasoning Engine

Efficient context inference with
extensible and adaptive reasoning rules

Villegas and Müller: *The SmarterContext Ontology and its Application to the Smart Internet: A Smarter Commerce Case Study*. (Springer 2013)

Contributions (3): The SMARTERCONTEXT Infrastructure



SmarterContext.

- Realizes dynamic context management across the context life cycle
  - Adaptive monitoring logic
  - Adaptive monitoring architecture

Villegas, Müller, *et al.*: *A Dynamic Context Management Infrastructure for Supporting User-driven Web Integration in the Personal Web*. In CASCON 2011 (ACM)

Tamura, Villegas, Müller, et al.: Improving Context-Awareness in Self-Adaptation using the DYNAMICO Reference Model. In SEAMS 2013

Evaluation:
Situation-Aware Smarter Shopping

To apply user-centric dynamic context management to improve user QoE

Ebrahimi, Villegas, Müller *and* Thomo: *A Context-aware Deal Recommendation System based on the SmarterContext Engine.* In CASCON 2012 (ACM). Best Paper Award (2012). CAS Project of the Year Award (2011)

Evaluation: Situation-Aware Smarter Shopping

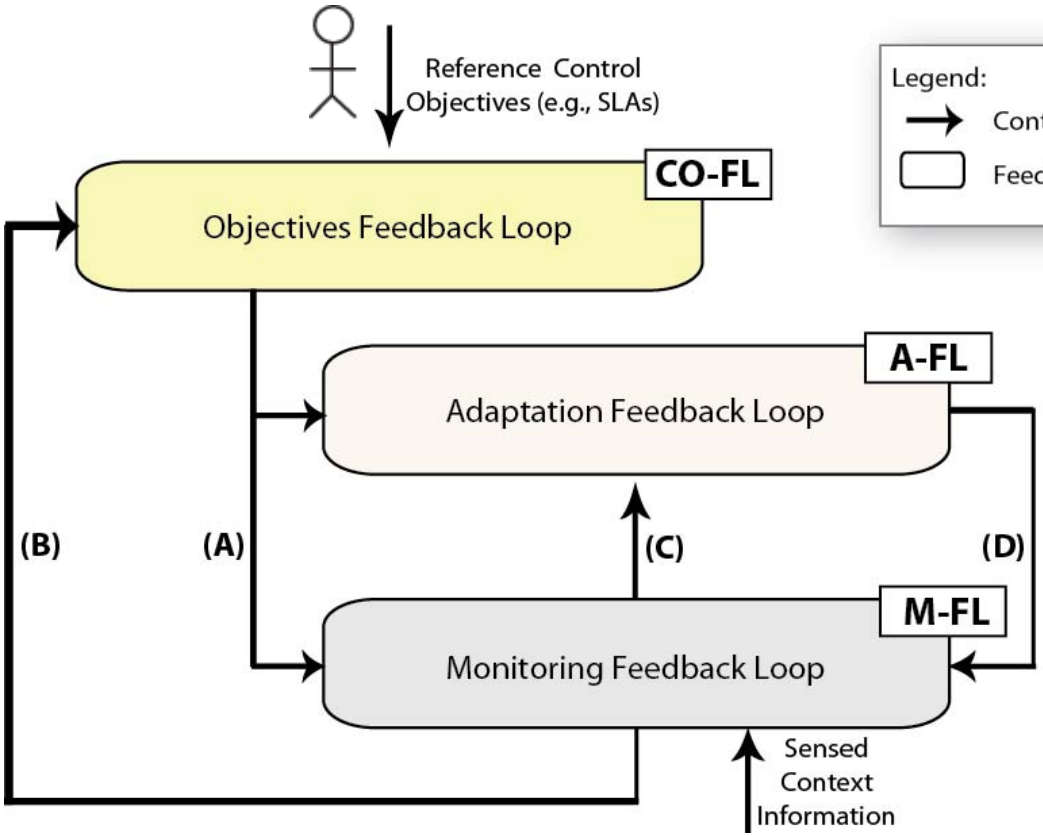
- Qualitative evaluation
  - Potential to enable new e-commerce business models
  - Applicability
- Quantitative evaluation
  - Effectiveness (accuracy of recommendations)
  - Efficiency (reasoning engine)

Four software prototypes

(SURPRISE, SMARTERCONTEXT engine, SMARTERCONTEXT infrastructure for shopping, SMARTERDEALS)

CONTRIBUTIONS ON REFERENCE MODELS FOR DYNAMIC SELF-ADAPTATION

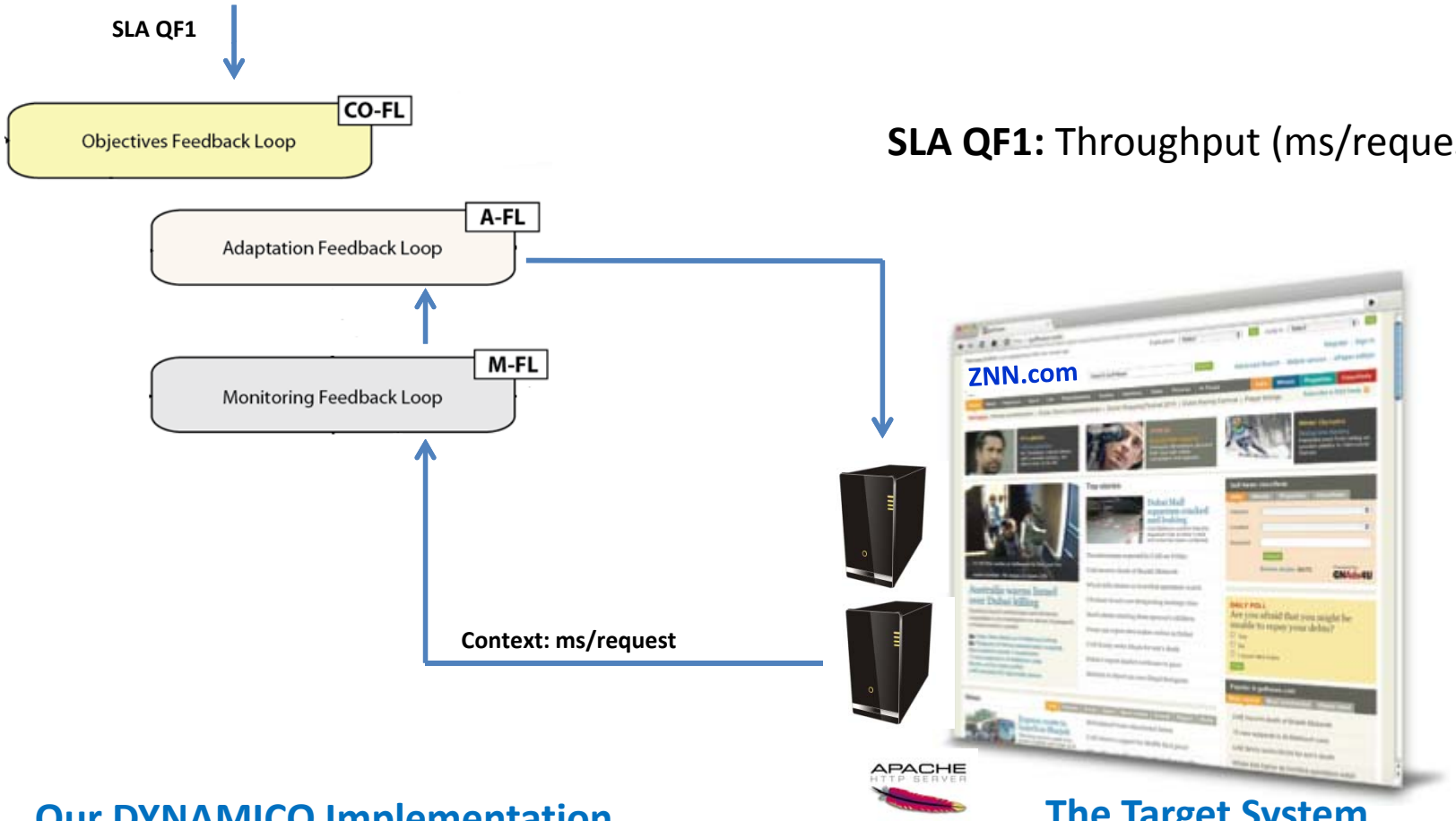
Contributions (4): DYNAMICO: Reference Model for Context-Aware Self-Adaptation



- Three levels of dynamicity
- Specific interactions clearly defined
- Goal: maintain context monitoring relevance

Villegas, Tamura, Müller, *et al.*: *DYNAMICO: A Reference Model for Governing Control Objectives and Context Relevance in Self-Adaptive Software Systems* (LNCS, 2013)
Villegas, Tamura, Müller, *et al.*: *Improving Context-Awareness in Self-Adaptation using the DYNAMICO Reference Model*. (SEAMS 2013)

Case Study: Znn.com

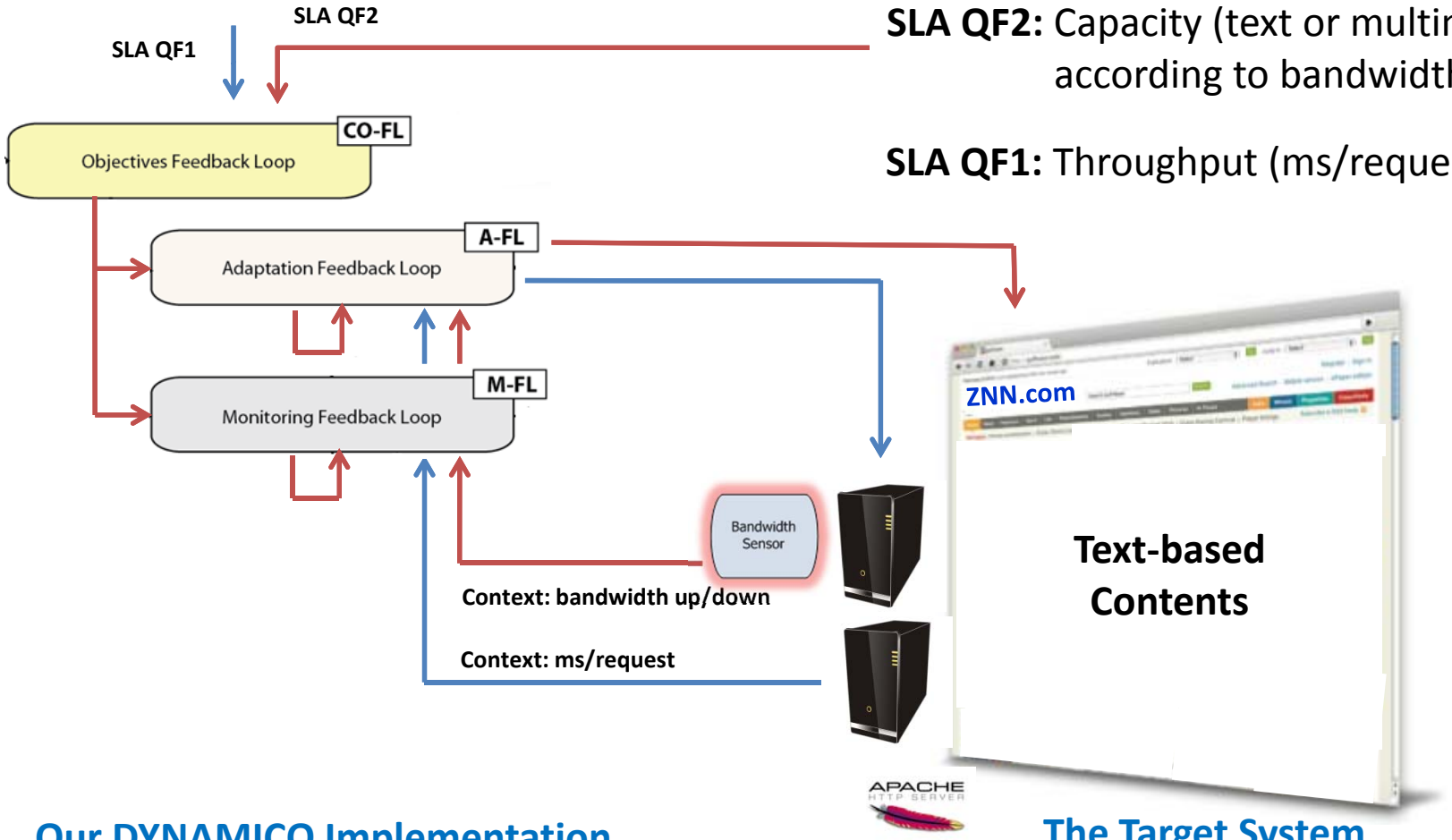


SLA QF1: Throughput (ms/request)

Our DYNAMICO Implementation
(QoS-CARE + SmarterContext)

The Target System
(response time and contents quality)

Case Study: Znn.com



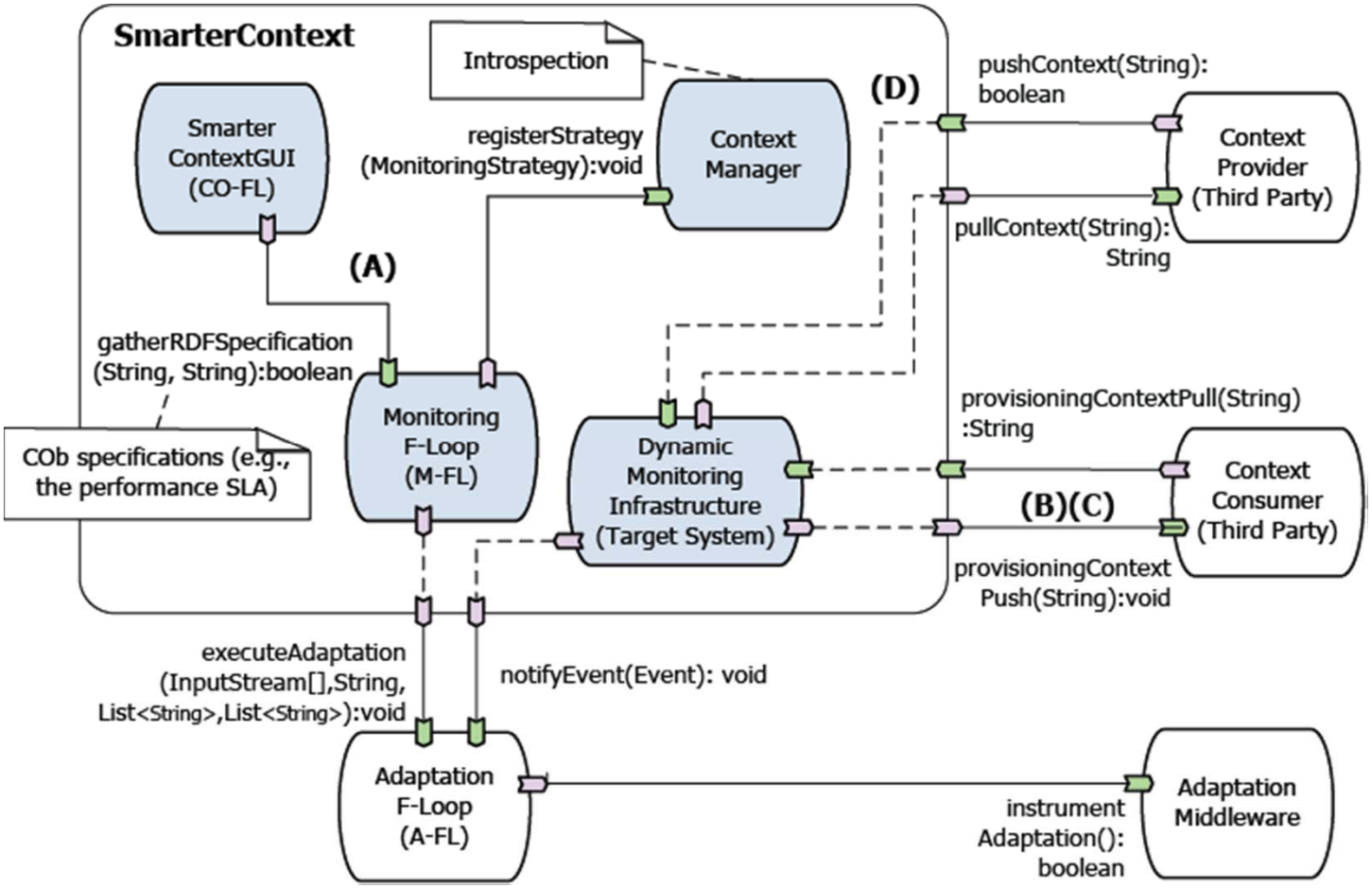
SLA QF2: Capacity (text or multimedia according to bandwidth)

SLA QF1: Throughput (ms/request)

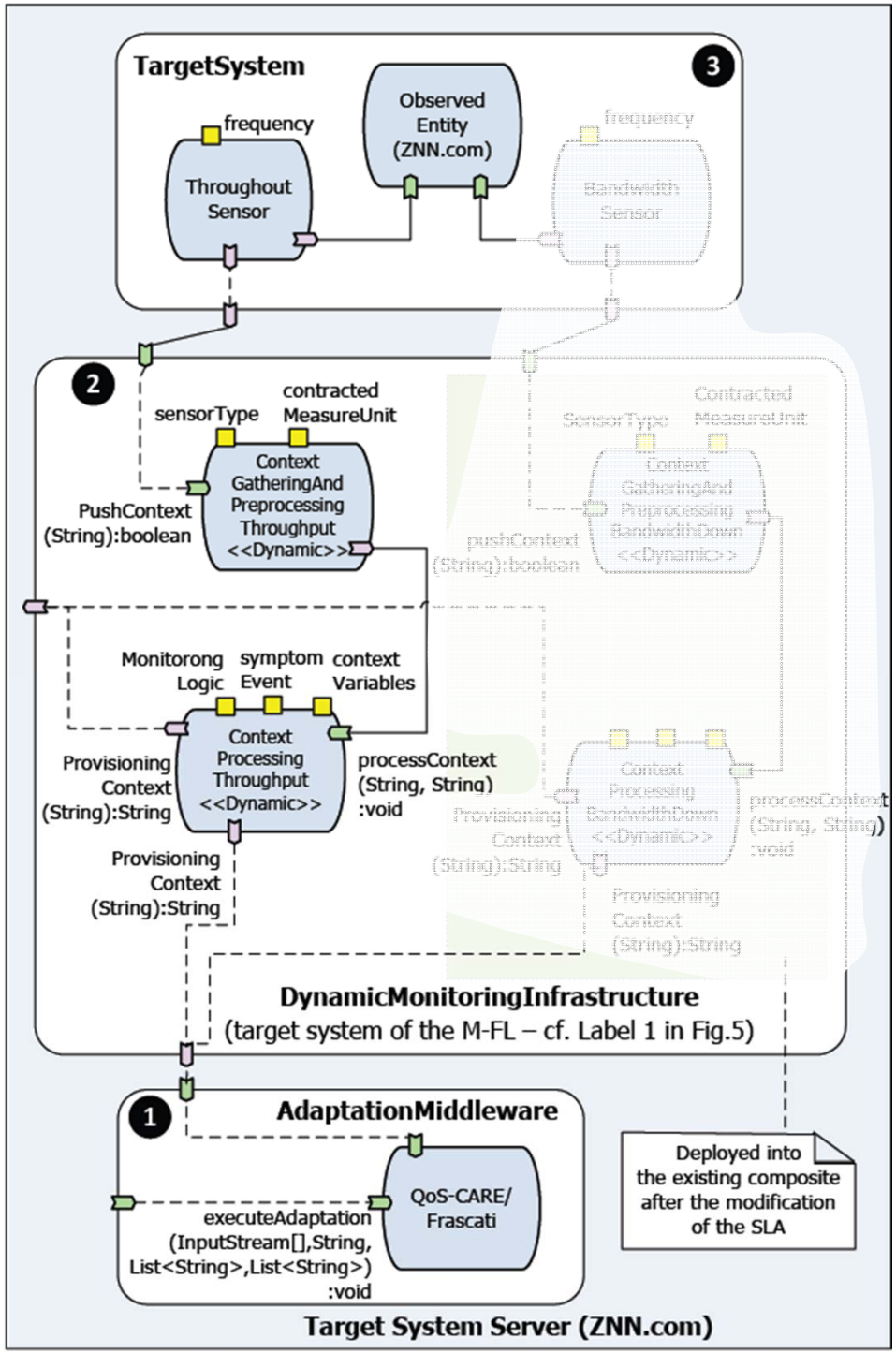
Our DYNAMICO Implementation
(QoS-CARE + SmarterContext)

The Target System
(response time and contents quality)

DYNAMICO: An Implementation (1)



- Hierarchical feedback-loops
- Context as a knowledge source
- Maintains context relevance wrt control objectives



DYNAMICO: An Implementation (2)

- Monitor probes, gatherers, and processors dynamically deployed

Villegas, Tamura, Müller, *et al.*: *Improving Context-Awareness in Self-Adaptation using the DYNAMICO Reference Model*. (SEAMS 2013)

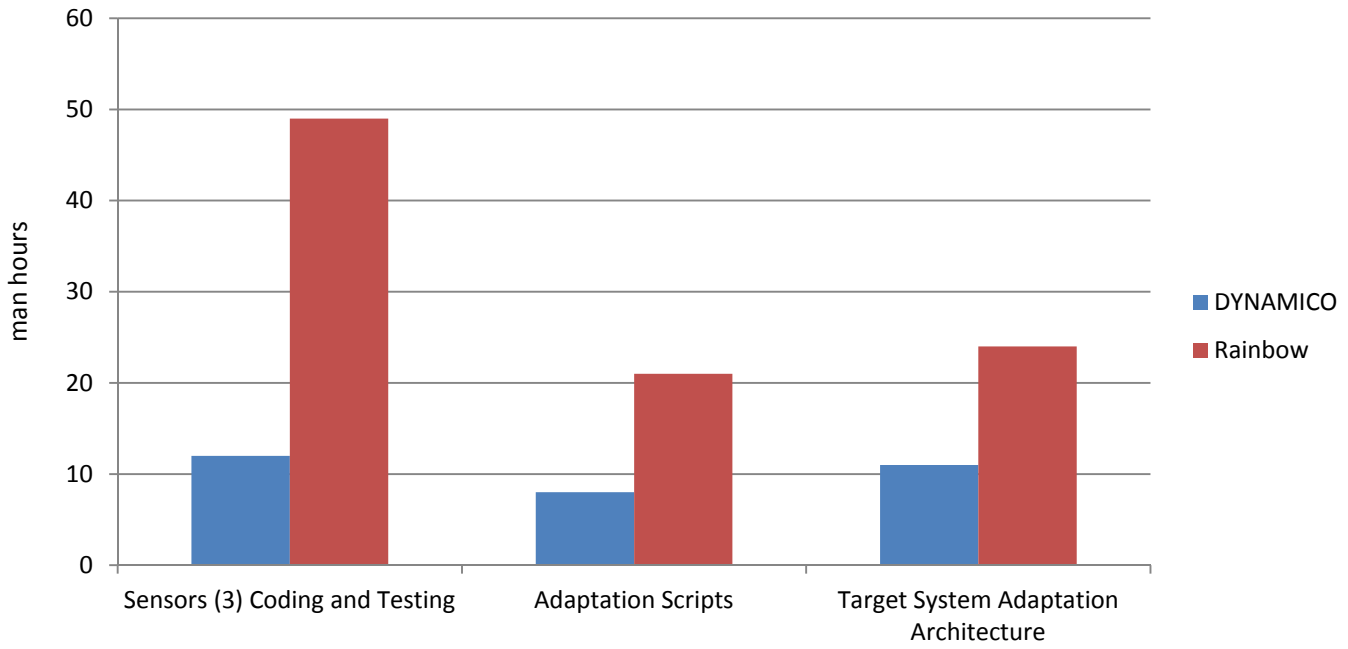
Evaluation

- Goal: To evaluate DYNAMICO's applicability and effectiveness
- Evaluation Scenario: based on the SEAMS's Rainbow/Znn.com reference exemplar
- Criteria:

Engineering Effort (man hours to add self-adaptive capabilities)	Performance (settling time and processing overhead)	Effectiveness (QoS preservation under changing contexts)

Evaluation Results (1)

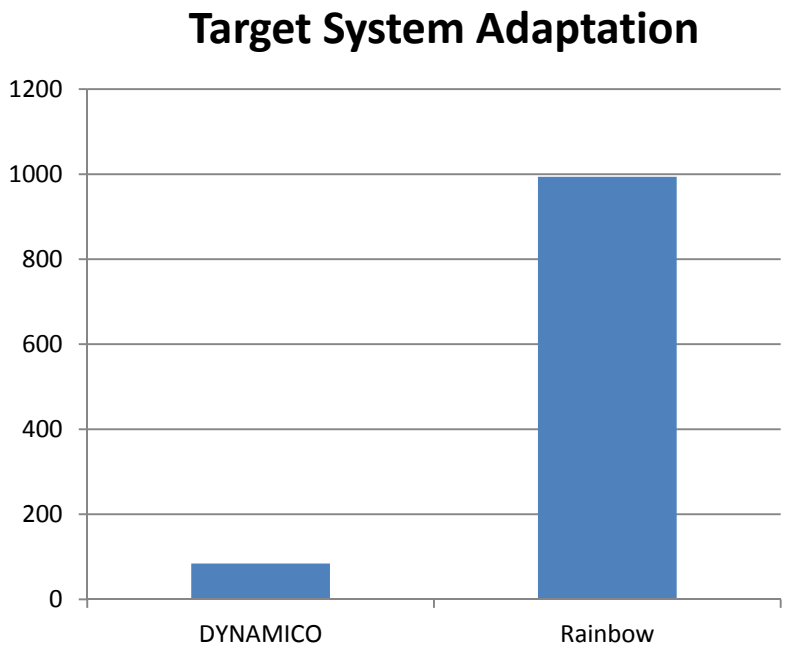
Engineering Effort (man hours)



Cheng et al.: *Evaluating the Effectiveness of the Rainbow Self-Adaptive System.* (SEAMS 2009)
Villegas, Tamura, Müller, *et al.*: *Improving Context-Awareness in Self-Adaptation using the DYNAMICO Reference Model*. (SEAMS 2013)

Evaluation Results (2)

Performance (settling-time)



Evaluation Results (3)

Performance (settling-time and overhead)

DYNAMICO: Monitoring Infrastructure Adaptation		
	SLA 1 (msec)	**SLA 2 (msec)**
CO-FL (Analyzing changes in goals)	698	732
M-FL (Analyzing the new monitoring strategy)	21	29
A-FL (Implementing the new monitoring strategy)	1,131	1,579
Total MTTR*	**1,850**	**2,340**
Target System Overhead	3	3

* Mean time to reconfigure

Evaluation Results (4)

Effectiveness (QoS Preservation under changing contexts)

Adapting the
Monitoring Infrastructure is a Key Factor
to Maintain Context Relevance and
Self-Adaptation Effectiveness

ONGOING AND FUTURE WORK

On Dynamic Context Management

- Monitors and Analyzers that exploit predictive analytics
- Uncertainty management through viability zones
- Industrial validation of SmarterContext in the e-commerce domain (for user-centric systems)
- Further development of the SmarterContext framework

On Reference Models and Models at Runtime for Self-Adaptation

- Runtime models for the assurance of self-adaptive systems at the three levels:
  - Objectives: requirements specifications
  - Adaptation: states of the managed system
  - Monitoring: context entities, monitoring requirements and strategies
- Runtime interactions among these models (causally connected)
- Runtime models for the management of viability zones

On Exemplars and Evaluation Frameworks

Ideal exemplars: based on the spectrum of adaptation strategies

Adaptation Spectrum

Znn.com is a good starting point. However, we need more versatile exemplars and evaluation frameworks.

Adaptation Dimension 2: Managed System's Structure

Non-modifiable structure

Modifiable structure
Software models and reflection

Villegas, Müller, Tamura, *et al*.: *A Framework for Evaluating Quality-Driven Self-Adaptive Software Systems*. (SEAMS 2011)

Selected Publications

- Norha Villegas's Dissertation: http://dspace.library.uvic.ca:8080/handle/1828/4476
- Tamura, Villegas, Müller, et al.: *Improving Context-Awareness in Self-Adaptation using the DYNAMICO Reference Model.* In Proceedings 8th International I Symposium SEAMS 2013, pages 153-162, ACM.
- Villegas and Müller. *The SmarterContext Ontology and its Application to the Smart Internet: A Smarter Commerce Case Study*, volume 7855 of LNCS, pages 151-184.Springer 2013.
- Villegas, Tamura, Müller, *et al.: DYNAMICO: A Reference Model for Governing Control Objectives and Context Relevance in Self-Adaptive Software Systems*, volume 7475 of LNCS, pages 265-293. Springer, 2013.
- Tamura, Villegas, Müller, *et al.: Towards Practical Runtime Verification and Validation of Self-Adaptive Software Systems*, volume 7475 of LNCS, pages 108-132. Springer, 2013.
- Villegas and Müller: *Managing Dynamic Context to Optimize Smart Interactions and Services*, pages 289-318. Springer-Verlag, Berlin, Heidelberg, 2010.
- Ebrahimi, Villegas, Müller, and Thomo: *SmarterDeals: A Context-aware Deal Recommendation System based on the SmarterContext Engine.* In CASCON 2012, pages 116-130, ACM.
- Muñoz, Tamura, Villegas, and Müller. *Surprise: User-controlled Granular Privacy and Security for Personal Data in SmarterContext.* In CASCON 2012, pages 131-145, ACM.
- Villegas, Müller, *et al*.: *A Framework for Evaluating Quality-driven Self-Adaptive Software Systems*. In Proceedings 6th International Symposium ICSE –SEAMS. 2011 pages 80-89, ACM.
- Villegas, Müller, *et al*.: *A Dynamic Context Management Infrastructure for Supporting User-driven Web Integration in the Personal Web*. In CASCON 2011, pages 200-214, ACM.