Lessons from IT Ecosystems

Michael Köster

Computational Intelligence Group,
Clausthal University of Technology
GaLOT Kickoff, February 11, 2013
Outline

1 IT Ecosystems

2 Loccom

3 Conclusion
IT Ecosystems
IT Ecosystems

- Classical approaches do not scale well for today’s large and complex software-intensive systems.
- Software systems are connected among each other and interact massively.

**IT Ecosystem:**

- analogue to biological ecosystems
- based on the balance between individuals (autonomy) and sets of rules (control) defining equilibria within an IT Ecosystem
- Maintaining and continuously evolving IT Ecosystems requires deep understanding of this balance.
IT Ecosystems

- **Classical approaches** do not scale well for today’s **large and complex software-intensive systems**.
- Software systems are **connected** among each other and **interact** massively.

**IT Ecosystem:**

- analogue to **biological ecosystems**
- based on the **balance between individuals** (autonomy) and **sets of rules** (control) defining **equilibria** within an **IT Ecosystem**
- **Maintaining** and continuously evolving IT Ecosystems requires deep understanding of this balance.
In *Smart Cities* are the following *IT Ecosystems*:

- Smart-Living-Systems
- Smart-Working-Systems
- Smart-Transport-Systems
- Smart-Energy-Systems
- etc.

⇝ *Smart Airport* as a smaller instance of a *Smart City*
Usual Day on an Airport:

- Journey to the Airport (Parking, Traffic Accident)
- Orientation
- Transportation in the Airport
- Shopping during Waiting time
- Goods Transport
- Check-in
- Baggage Drop-off
- Catastrophe
- etc.
IT Ecosystems Project

NTH focused Research School for IT Ecosystems:

- Technische Universität Braunschweig,
- Technische Universität Clausthal,
- Leibniz Universität Hannover.

Three main projects:

- **AIM**: Bottom-Up Approach
  Adaptive Information methods.

- **RuleIT**: Top-Down Approach
  Rules are inferred from the design phase and verified at runtime.

- **Loccom**: Combination of both: Bottom-Up and Top-Down approaches.
Loccom
Project Loccom

Professors:

- Prof. Dr. Lars Wolf (TUBS)
- Prof. Dr. Jürgen Dix (LUH)
- Prof. Dr. Michael Beigl (TUBS, jetzt KIT)
- Prof. Dr. Christian Siemers (TUC)
- Prof. Dr. Heribert Vollmer (LUH)
- Prof. Dr. Mark Vollrath (TUBS)

Research Assistants:

- Martin Berchtold
- Kerstin Bischoff
- Michael Köster
- Peter Lohmann
- Sascha Lützel
- Johannes Morgenroth
- Julian-Steffen Müller
- Klaus Reinprecht
- Sebastian Schildt
- Sergej Zerr
Loccom: Local Communities

Nowadays **Social Networks:**

- exchange of information,
- groups of interests, and
- explicit use of a computer or smartphone.

Local Communities: **social networks + real social networks**

- exchange of information works automatically,
- spontaneous and dynamic groups of interests, and
- implicit use of a smart phone.
Loccom: Local Communities

Nowadays Social Networks:
- exchange of information,
- groups of interests, and
- explicit use of a computer or smartphone.

Local Communities: social networks + real social networks
- exchange of information works automatically,
- spontaneous and dynamic groups of interests, and
- implicit use of a smart phone.
**Overall Aim and Loccom Approach**

**Goal:** Combine social and real social networks by
- integrating the context
- ensuring minimal properties
- using resources jointly.

**Approach:** Use mobile devices to combine social network services with the real world.
**Konzept**

- **AP1: Logisches Modellieren**
- **AP Psy: Akzeptanzanalyse, Benutzerstudien**
- **AP 2: Deduktive skalierbare Inferenzmethoden**

**Software**

- **AP5: Kontextspezifischer Informationsaustausch**
- **AP3: Kontexterkennung**
- **AP 4: Kommunikation**
- **AP 6: Adaptive Hardwarearchitekturen**

**Hardware**

- „SmartFolk“ Smartphone Plattform
- „SmartBases“
- Sensorik
- Custom Computing Machine (CCM)
Local Communities: social networks + real social networks
- exchange of information works automatically,
- spontaneous and dynamic groups of interests, and
- implicit use of a smart phone.

Specification: Modular Interpreted System
State Space: Abstraction for MIS
Minimal Properties: ATL, MDL, MTL
Model Checking AMIS
Model Checking AMIS

Idea:

- **Input:**
  - MIS $S$
  - $init$ of global states of $S$
  - ATL formula $\varphi$
  - for each quantifier subformulae an abstraction relation

- **Output:**
  - **true:** if $S, q \models \varphi$ for all $q \in init$
  - **unknown:** we do not know whether $S$ satisfies $\varphi$ or not
Modal Dependence Logic

**Dependence** between propositions.

Complexity results:
- Model Checking: NP-complete
- Satisfiability: NEXPTIME-complete
- $\bowtie$ Fragments for MDL satisfiability.
Modal Team Logic

No dependence between propositions.

Complexity results:

- Model Checking: PSPACE-complete
- Fragments for MTL Model Checking:
Opportunistic Networks

- DTN Networks
- Agents’ Goals in CTL
- Game-theoretic Approach for Optimal Topology
DTN Communication

- Opportunistic Networks
- Underlying communication infrastructure in a SmartCity
- Integration in Android
Context Recognition

Real World -> Sensory Extraction -> Feature Vector

Signal -> Sampled Signal

Mapping Function -> Fuzzy Numbers

Mapping Value -> Class Uncertainty

Filter \( \mu \geq \tau \)
Privacy and Data Sharing: Classification

Classification of images:

Private

Public

Work

Sea

Winter

Water
Conclusion
Ongoing Work

Parallel (approximate) Model Checking for MIS:
- Model Checking happens in the modules
  - Constrain ATL formulae: Length of path and/or nesting
  - Look only at the states in the direct neighbourhood
- Implement the algorithm in JAVA.
- Translate the algorithm to cellular automata to use FPGAs.
Lessons learned

Problems:
- A formal description of an IT Ecosystem was missing.
- The Scenario was quite vague.
- Heterogeneous group of researchers even in the smaller projects.

Interesting Aspects:
- Working with researchers from different fields.
- Underlying idea of an IT Ecosystem.