2018-00798 - Dynamic adaptation of middleware-layer protocols for emergent mobile systems

Level of qualifications required: Graduate degree or equivalent
Fonction: PhD Position

Context

Given the prevalence of mobile networking environments and systems (e.g., smartphone applications), physical-world sensing and actuation devices (e.g., embedded in handhelds and wearables), and IT systems hosted on global networking and computing infrastructures (e.g., the Internet, the cloud), the possibilities of emergent mobile systems have reached unprecedented levels. Such systems are dynamically composed according to networked resources in the environment, which is not anymore limited to the immediate neighborhood of the users. This perspective is in accordance with the various viewpoints, definitions, and envisaged solutions found in the research literature and practice that constitute the vision of the Future Internet and, one of its growing constituents, the Internet of Things.

Emergent mobile systems integrate system domains – enumerated above – that differ significantly in terms of interaction paradigms, communication protocols, and data representation models, provided by supporting middleware platforms. Specifically considering interaction paradigms, the client/server, publish/subscribe, tuple space, and data streaming paradigms are among the most widely employed ones today, with numerous related middleware platforms. Hence, enabling emergent mobile systems calls for advanced interoperability solutions at the middleware layer.

Existing cross-domain interoperability efforts are based on bridging communication protocols, wrapping systems behind standard technology interfaces, and/or providing common API abstractions. In particular, such techniques have been applied by widely established system integration paradigms, such as Service Oriented Architecture (SOA), Enterprise Service Bus (ESB), or simply the Web. However, state-of-the-art interoperability efforts poorly address cross-domain interoperability, with integration solutions that: (i) lack precise comprehension of constituent systems’ interaction semantics versus end-to-end semantics of the integration; (ii) are typically static, which makes them inapplicable to emergent mobile systems; and (iii) do not offer Quality of Service (QoS) guarantees for the end-to-end integration.

In the MiMove team, we have been working on interoperability solutions for emergent mobile systems. We model and analyze formally the interaction semantics of middleware protocols and paradigms by relying on the connector abstraction from the software architecture field. This enables developing solutions to the composition of middleware protocols. More precisely, we build connector models for both the internal and composed protocols by relying on process algebras, and verify their time-coupling and concurrency semantics by employing temporal logic notations and related verification tools. Based on this analysis, we construct protocols converters that enable the interconnection of such protocols [Georgantas13].

Regarding QoS, we develop modeling and analyses of end-to-end properties of the interconnected systems. We rely on formal (based on timed automata) and stochastic (based on queueing networks) models and, when available, on massive real datasets. More precisely, we model and analyze QoS properties such as timeliness and data delivery success rate, which characterize middleware-layer connectors as well as their end-to-end interconnection [Kattepur15]. This covers queueing phenomena on the connections, freshness of data, and the stochastic nature of input and output data traffic; the latter one depends on the behavior of applications and their users employing the middleware connectors. We verify timing conditions with formal verification tools and elicit analytical queueing models for the connectors. We validate both the previous by developing and running customized simulators, relying on probabilistic input models as well as large-scale extensive-timespan mobile datasets (e.g., Call Detail Records) [Bouloukakis15].

While in the previous we focus so far on design-time analysis, our objective is to investigate in our next step runtime analysis.

Assignment

In the above context, this thesis will aim at enabling runtime-adaptive middleware connectors for emergent mobile systems. The targeted solution will feature:

- Dynamic automated adaptation of middleware protocols. Based on the elicited middleware connector models, analysis and mapping of interaction semantics of constituent systems

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General Information

- Theme/Domain: Distributed Systems and middleware
- System & Networks (BAP E)
- Town/city: Paris
- Inria Center: CRI de Paris
- Starting date: 2018-07-01
- Duration of contract: 3 years
- Deadline to apply: 2018-06-30

Contacts

- Inria Team: MIMOVE
- Recruiter: Georgantas Nikolaos / niko10as.georgantas@inria.fr

About Inria

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Conditions for application

Defence Security:

This position is likely to be situated in a restricted area (ZRR), as defined in Decree No. 2011-1425 relating to the protection of national scientific and technical potential (PPST). Authorisation to enter an area is granted by the director of the unit, following a favourable Ministerial decision, as defined in the decree of 3 July 2012 relating to the PPST. An unfavourable Ministerial decision in respect of a position situated in a ZRR would result in the cancellation of the appointment.

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towards the integrated system need to be carried out at runtime. The aim is to enable emergent mobile systems that are adaptive in a dynamic context based on runtime-acquired knowledge. In particular, reconfiguration of end-to-end middleware connectors will be enabled during the lifetime of the integrated system.

- **QoS-aware adaptation of middleware protocols.** Besides interaction semantics of emergent mobile systems, their end-to-end QoS needs to be ensured at runtime. The aim is to dynamically manage the QoS and resource characteristics and needs of the constituent systems and the integrated system, e.g., by leveraging synergies between mobile, resource-constrained devices and the cloud for acquiring on-demand resources and for dynamically offloading part of the computation. In particular, adaptation will require taking appropriate action, for instance, replacing a disconnected or low-performing system by another, substituting a middleware connector, or reserving on-demand additional resources for a system.

- Besides its formal foundation, the above work will be practically validated through the implementation of enabling software infrastructure that will support runtime-adaptive middleware connectors for emergent mobile systems.

**Main activities**

**References**


**Skills**

The candidate should have a Research Master's in Computer Science with expertise – including experience in the implementation of related software prototypes – in one and possibly several of the following topics:

- Mobile distributed systems,
- Middleware architectures and protocols,
- Software engineering,
- System modeling and analysis.

**Benefits package**

- Subsidised catering service
- Partially-reimbursed public transport