Service Contracts in a Secure Middleware for Embedded P2P Systems

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Introduction

- Mobile peer-to-peer systems
  - All network elements can act both as service consumers and as service providers, enormous potential for distributed applications …
    - communication often relies on dynamic ad-hoc networks
    - constantly changing topology
    - frequent connections and (possibly unexpected) disconnections
  - Two important derived issues:
    - “Exception is the rule”
    - Security
  - Need of appropriate middleware to abstract from low-level issues while developing P2P applications

The SMEPP project

- Ongoing EC project "**S**ecure **M**iddleware for **E**mbedded **P**eer to **P**eer Systems" (www.smepp.org)
- Goal: To develop a middleware for EP2P that will have to be
  - **secure**
    - supporting and facilitating the use of different levels of security for different (parts of) applications
  - **versatile**
    - adaptable to different devices (from laptops to PDAs and smart phones to sensor networks)
    - usable in different application domains (from critical systems to domotics to consumer entertainment)
  - **service-oriented**
    - to enable programming applications at a suitable abstraction level

The SMEPP project

- The analysis of the state-of-the-art highlighted that available P2P models:
  - do not provide a simple, high-level service model to ease the development of P2P applications, or
  - do not model all concepts emerged in the definition of SMEPP's middleware and application requirements, or
  - do not provide a (formal) abstract language that can be used for simulating and verifying the behaviour of peers and services, as well as for application prototyping
- SMEPP therefore introduced
  1) A service-oriented model and a set of primitives for programming secure (E)P2P applications
  2) A simple modelling language (SMoL) to specify peers and services by orchestrating SMEPP primitives

SMEPP primitives

Key notions of the model

- **group** of peers
- **service** offered by peers or groups
- **security-awareness**

```
// Peer Management
pId newPeer(creds)
pId getPeerId(id?)
pId[] getPeers(gId)

// Group Management
gId createGroup(grDescr)
gId[] getGroups(grDescr?)
grDescr getGroupDescr(gId)
void joinGroup(gId, creds)
void leaveGroup(gId)
gId[] getIncludingGroups()
gId getPublishingGroup(id?)
```

```
// Service Management
<gSId, pSId> publish(gId, contract)
void unpublish(pSId)
<gId, gSId, pSId>[]
   getServices(gId?,pId?, contract?, creds)
contract getServiceContract(id)
sessId startSession(sId)

// Message Handling
out? invoke(eId, opName, in?)
<cId, in?> receiveMessage(gId?, opName)
void reply(cId, opName, out?, fName?)

// Event Handling
void subscribe(evName?, gId?)
void unsubscribe(evName?, gId?)
void event(gId?, evName, in?)
<cId, in?> receiveEvent(gId?, evName)
```

SMoL (**SM**EPP M**o**delling **L**anguage)

- Objective
  - Provide a high-level language for specifying how to orchestrate SMEPP primitives into peer or service code
    - to simplify the time-consuming and error-prone task of specifying the interactions of a complex P2P system.
  - Define formal semantics for such a language
    - to enable the simulation and the analysis of the behaviour of peers and services
    - in order to feature the possiblitiy of developing not only secure, but also *a priori* verified SMEPP specifications
  - Simplify the generation of executable code by means of automatic translators
    - eg, the prototype SMoL2Java compiler

SMoL (**SM**EPP M**o**delling **L**anguage)

- Inspired by WS-BPEL 2.0

  (the OASIS standard to orchestrate several WSDL services)

  but removing from WS-BPEL the constructs (not needed for SMEPP) that make its semantics hard to be analysed, like synchronisation links or compensations

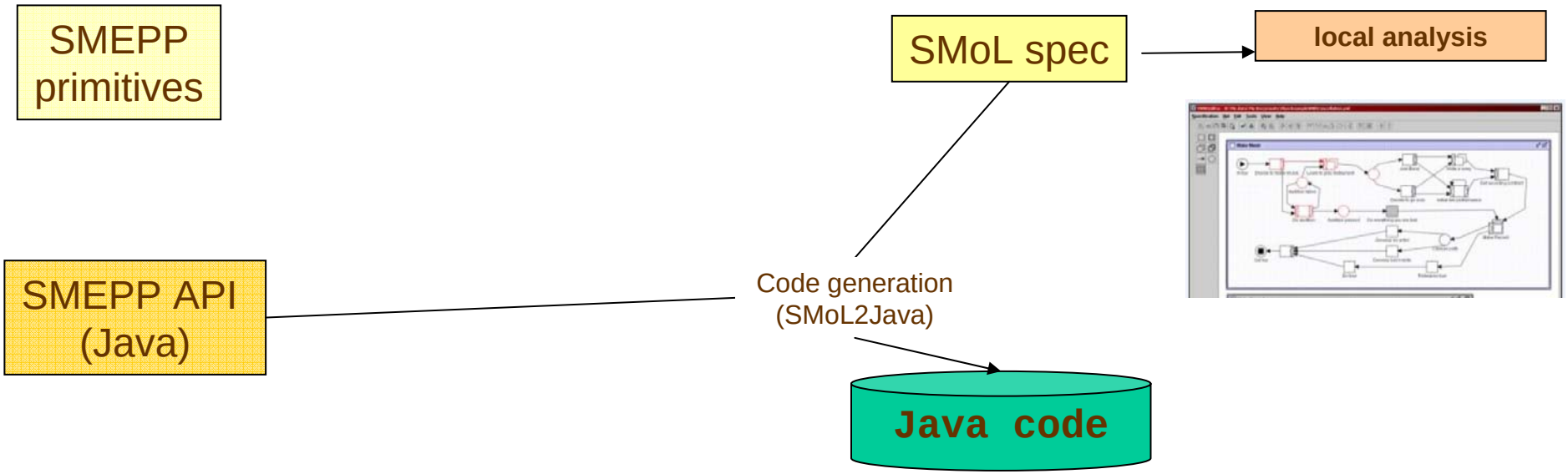
SMoL syntax

```
basicCommand ::= P | empty() | wait(for?,until?,repeatEvery?) |
                 throw(faultName,faultVariable?) |
                 catch(faultName) | catchAll() |exit()

C ::=
 basicCommand |
 Assign from to |
 Sequence(C,…,C) |
 Flow(C,…,C) |
 While cond Do C | Repeat C Until cond |
 If cond Then C Else C |
 Pick(guard → C + ... + guard →C) |
 InformationHandler (/*while*/ C Do guard → C + ... + guard → C) |
 FaultHandler (/*while*/ C Do fhGuard → C + ... + fhGuard →C)


guard ::= receiveMessage(…) | receiveResponse(…) |
          receiveEvent(…) | wait(…)
guard ::= receiveMessage(..) | receiveEvent(..)| wait(..)
fhGuard::= catch(..) | catchAll(..)
```

Summary of contributions so far

- Contributions
  1) A service-oriented model and a set of primitives for programming secure (E)P2P applications
  2) A simple modelling language (SMoL) to specify peers and services by orchestrating SMEPP primitives
  3) Semantics for SMoL
     - a transformational semantics for SMoL – via a pattern-based compositional translation of SMoL programs into YAWL workflows
     - a sequent-calculus semantics for an abstract version of SMoL - it allows to determine whether a set of peer and service specifications can be executed together without locks

Incremental software development in SMEPP



Incremental software development in SMEPP

αSMoL spec

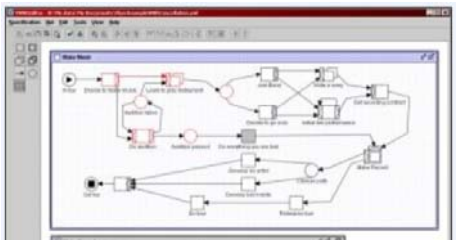
global analysis

$$\frac{P \qquad \Gamma \rightsquigarrow \Pi}{\Gamma' \rightsquigarrow \Pi'}$$

SMEPP primitives

SMoL spec

local analysis



SMEPP API (Java)

Code generation (SMoL2Java)

Java code

Incremental software development in SMEPP

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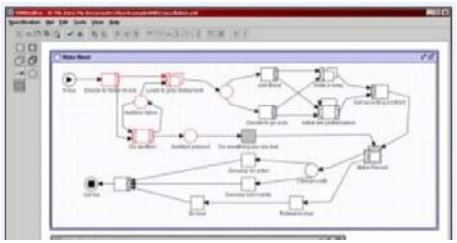
SMEPP primitives

SMoL spec

local analysis



SMEPP API (Java)

Code generation (SMoL2Java)

Java code

SMEPP service contracts

- SMEPP services are associated with:
  - **service contracts** - which provide standard descriptions of SMEPP services - and with
  - service groundings - which provide metadata needed to correctly interoperate with (third-party) services
    - communication protocols, message formats, port numbers, etc.
    - grounding information accessible only by the provider's MW
- Service contracts are the key ingredients of the SMEPP mechanisms for service publication, discovery, and analysis

$[\text{contract}]_{\text{SMEPP}}$ = self-presentation of a service

FLACOS'08 discussions → Need of clearly distinguishing *self-presentations of services* from *inter-party agreements contracts*

SMEPP service contracts

- **Signature information**
  - Operations, events, parameters, types
  - Ontological annotations [optional]
  - Signature information used for discovery, needed for service invocation
  - Expressed with (a subset of) WSDL2.0 [and OWL]
- **Behaviour information**
  - Term representing the interaction behaviour of the service (orchestration of SMEPP primitives)
  - Behaviour information is optional (state-less services)
  - Behaviour information used for discovery and analysis
  - Expressed as a SMoL specification
- **Properties [optional]**
  - Service categorization according different criteria (e.g., geographical, business type)
  - Used for discovery
  - List of properties of the form *<category,name,value>*

    category can be a reference to a taxonomy
- **QoS information [optional]**
  - List of QoS parameters, each can include
    - *Name, Valure*
    - *Domain* - classification of the information (e.g., Runtime-related, Transaction-Support, Security-Level, Cost-related, etc.).
    - *QoSImpact* - describes the way in which a variation or unfulfillment of the QoSParameter would affect the performance and QoS of the service
    - *QoSMetric* – measure unit with which the QoSParameter can be measure
    - *RelationShip - describes how the* QoSParameter *can affect other* QoSParameters
    - *Aggregations - compositional rules applied to the* QoSParameter*, used to describe compound* QoSparameter*….*
  - Ontological annotations [optional]
  - Format borrowed from AMIGO project
  - Used for discovery (and for monitoring**)**

Simple example of SMEPP contract

```
Begin_Contract:

Profile:
      ServiceName: TemperatureReader
      ServiceCategory: EnvironmentMonitoring

Signature:
      Request-response operation temperature getTemp()

Behaviour:
      ServiceType: state-less
      Process:
            Sequence
                  <callerId> = receiveMessage("getTemp")
                  t = opaque // measure ambient temperature
                  reply(callerId, "getTemp", t)
            End Sequence

Properties:
      [Geography::Location] = "Italy";
      [Business::Functionality] = "Environmental Sensor"

QoS:
   -  [Transaction_Support::integrity] = 100'%'
   -  [Runtime_Related::latency] = 5'sec'
      latency produces an inverselyProportional impact over performance
   -  [Runtime_Related::throughput]  = 1000'request per hour'
      throughput produces a proportional impact over performance
   -  [Runtime_Related::performance]  = 100'%'
      performace is a compound QoSParameter composed by latency and throughput

End Contract
```

(friendly syntax)

Concluding remarks

- Service discovery = service localization + matching
- SMEPP service localization
  - group-aware, scalable and capacity-aware
  - prototype implementation based on a Chord-like overlay network
- SMEPP service discovery
  - relies on service contracts and on queries expressing partial contract specifications
  - current prototype implementation supports syntactic queries – taking into account ontological annotations, if any
  - future activities
    - provide (user-friendly) editor for contracts
    - experiment resource requirements for the different types of devices participating in SMEPP applications
    - develop semantics- and behaviour-based matching algorithms
      - identify a suitable, less expressive language (e.g, αSMoL, behavioural types or even FSMs) to represent service behaviour, in order to make their inclusion in the matching feasible in the context of SMEPP
    - devise different types of matching for the different middleware configurations

What I should have talked about, maybe

- **Contract-based service discovery** (using PNs and WFs)
  - A. Brogi, S. Corfini. Behaviour-aware discovery of Web service compositions. International Journal of Web Services Research, 4(3), pages 1-25, 2007.
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- **Contract-based service composition** (using PNs and WFs)
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- **Contract-based service adaptation** (using PAs and WFs)
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  - A. Brogi, C. Canal, E. Pimentel. On the semantics of software adaptation. Science of Computer Programming, 61(2): 136-151, 2006.
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  - A. Brogi and R. Popescu. Automated Generation of BPEL Adapters. In Dan and Lamersdorf, editors, ICSOC'06, volume 4294 of LNCS, pages 27–39, Springer, 2006.
- **Bisimulation-based compositional equivalence for Web services** (using PNs)
  - F. Bonchi, A. Brogi, S. Corfini, F. Gadducci. On the use of behavioural equivalences for Web services' development. Fundamenta Informaticae, 2009. (To appear.)
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  - A. Brogi, C. Canal, E. Pimentel. Behavioural types for service inte
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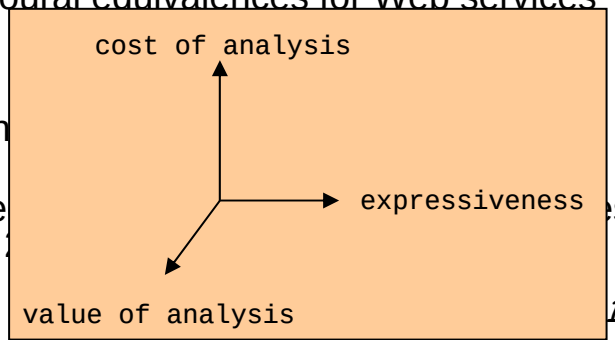

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