# Architecture-based Dependability Prediction for Service-oriented Computing

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# Service-oriented Computing

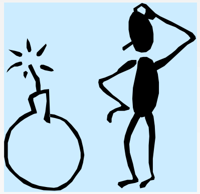
- emerging paradigm for designing, architecting and delivering distributed applications
  - applications built as a composition of Internet accessible, independently developed and delivered “services”
  - “service”: unit of composition, spans high level functionalities (some complex business logic) and basic functionalities (processing, storage, …)
- strong overlapping with component-based approaches
  - distinguishing feature: **automatic** service advertisement, discovery and composition
    - need of agreed on and machine-processable service description languages
    - need of automatic discovery, selection and composition tools

# QoS-driven service selection and composition

- Non obvious correlation between service assembly QoS and individual services QoS

  - assembly QoS *monitoring* to assess the fulfillment of some QoS goal, **after** the service selection and composition

  - assembly QoS *prediction* **to drive** the selection of services



need of QoS prediction methodologies

- *compositional* (to exploit the SOC application structure)
- *automatic* (to be compliant with the SOC requirements)

in this work, focus on dependability issues

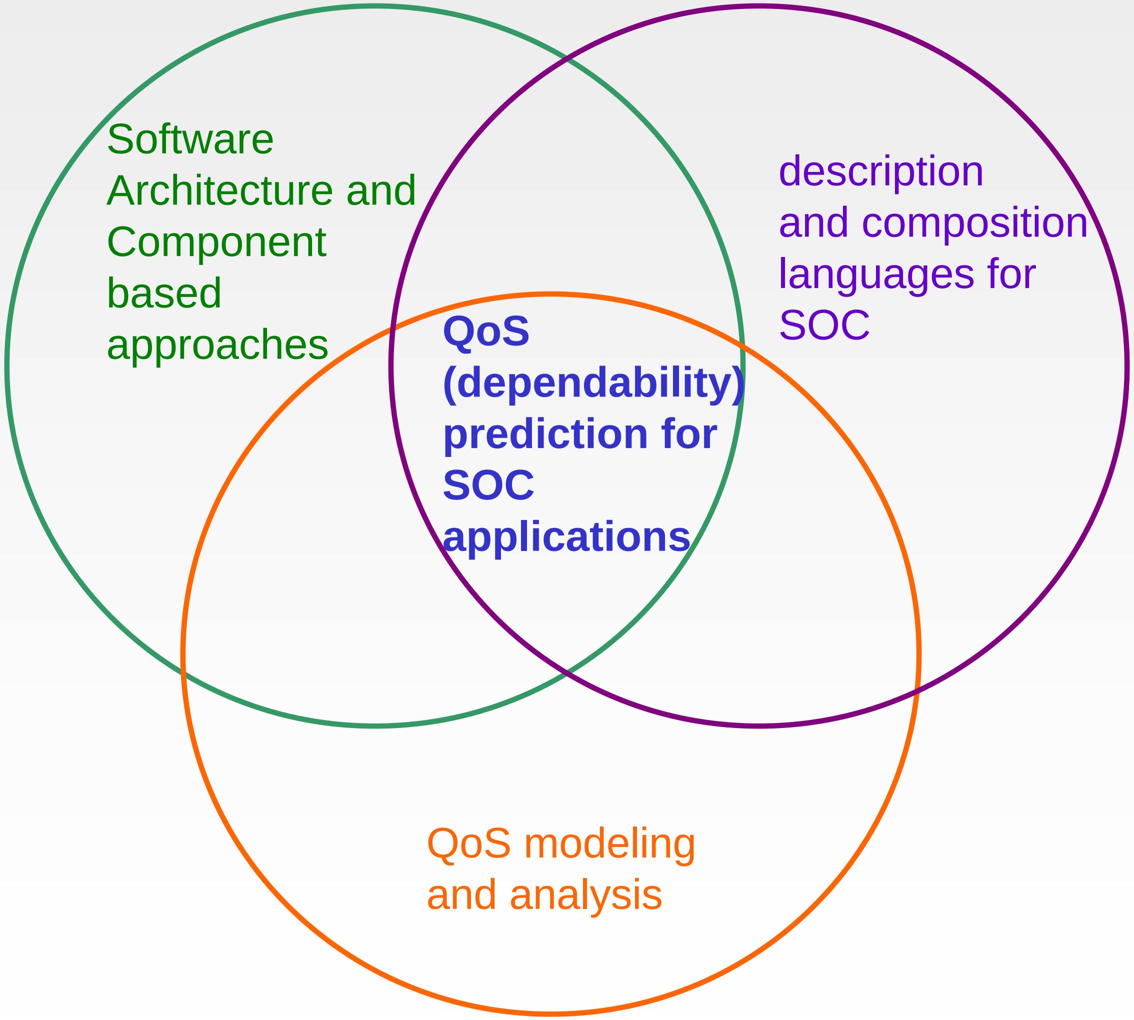
# Compositional and automatic QoS (dependability) prediction (1)

- need of a **QoS language** for SOC
  - machine-processable
  - integrated with existing SOC languages
  - supporting compositionality

- built to express which concepts ?
  - syntax
  - semantics

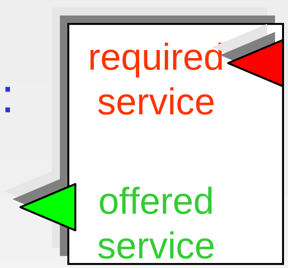
# Compositional and automatic QoS (dependability) prediction (2)

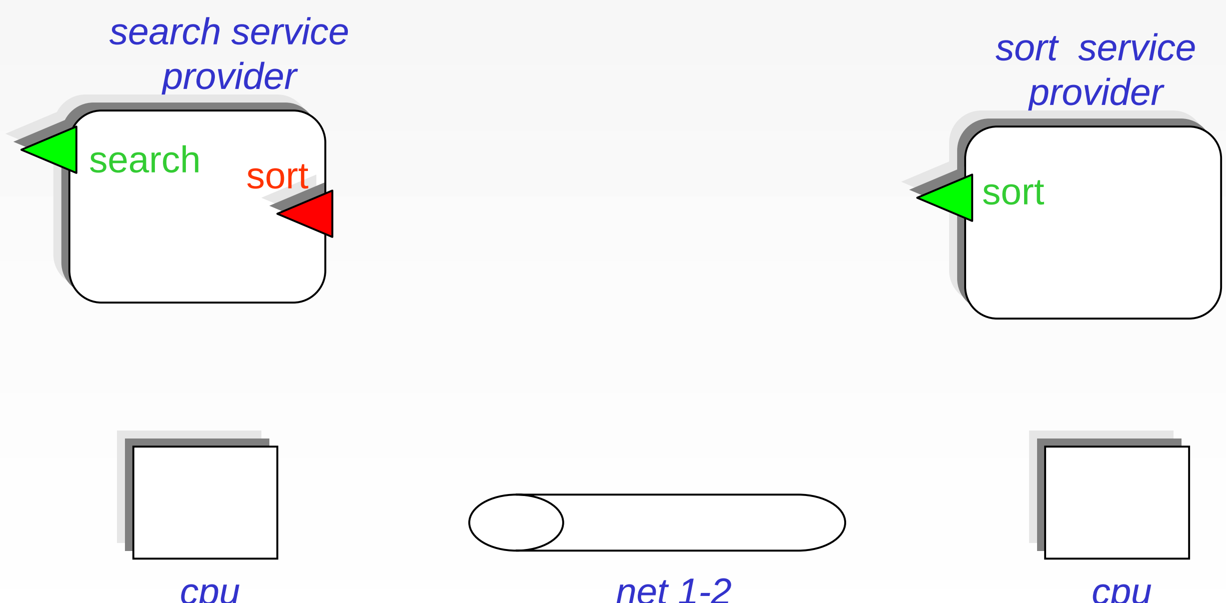
- Contributions from different areas and communities



# Example

- “search an item in a list" service
  - can require a "sort" service if the list is not ordered
- symbols :



# Contributions from each area (1)

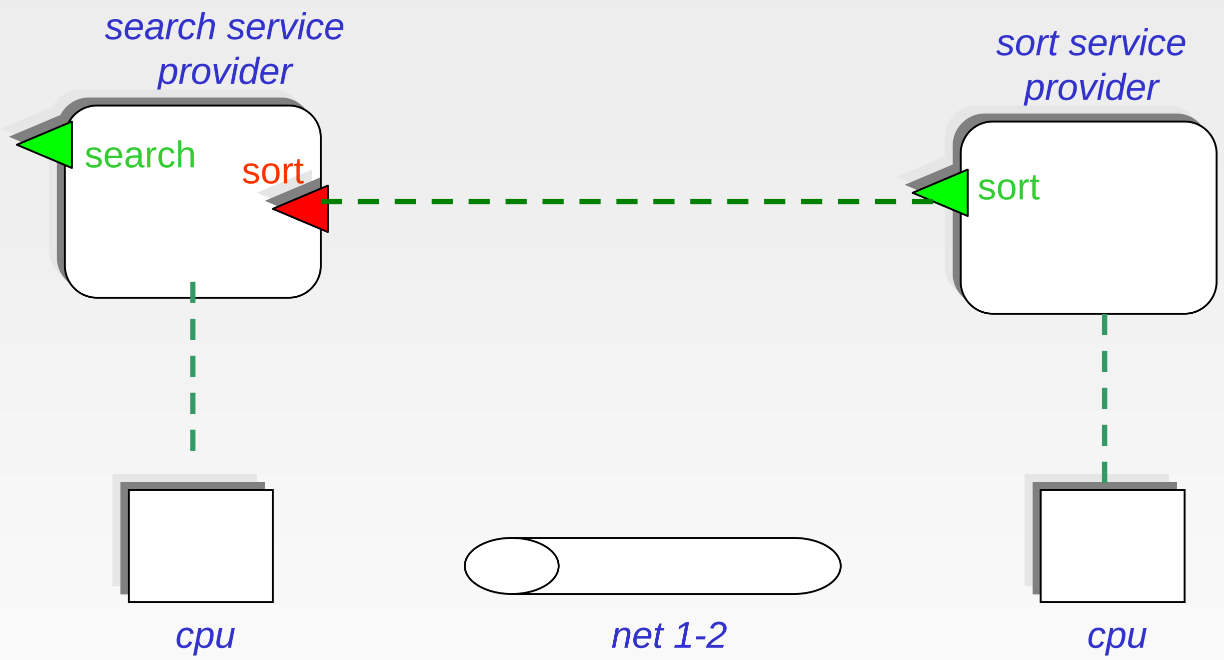
- description and composition languages for SOC
  - built on top of basic XML-based languages and protocols (WSDL, SOAP, UDDI)
  - examples
    - OWL-S (formerly DAML-S): promoted by BBN Technologies, Nokia, and several academic institutions (CMU, Stanford, USC, MIT, Vrije Univ., …)
    - BPEL4WS (formerly WSFL and XLANG): promoted by BEA, IBM, Microsoft, SAP AG, Siebel Systems

- main features
  - machine-processable and interoperable
  - support the definition of non functional properties (e.g. reliability)

  but …

  - no explicit description of  the "interaction infrastructure"
  - QoS values mainly expressed as absolute values (no platform dependent parameterization)
  - lack of support for compositional analysis

# Example


search service
provider
search
sort
sort service
provider
sort
cpu
net 1-2
cpu

# Contributions from each area (2)

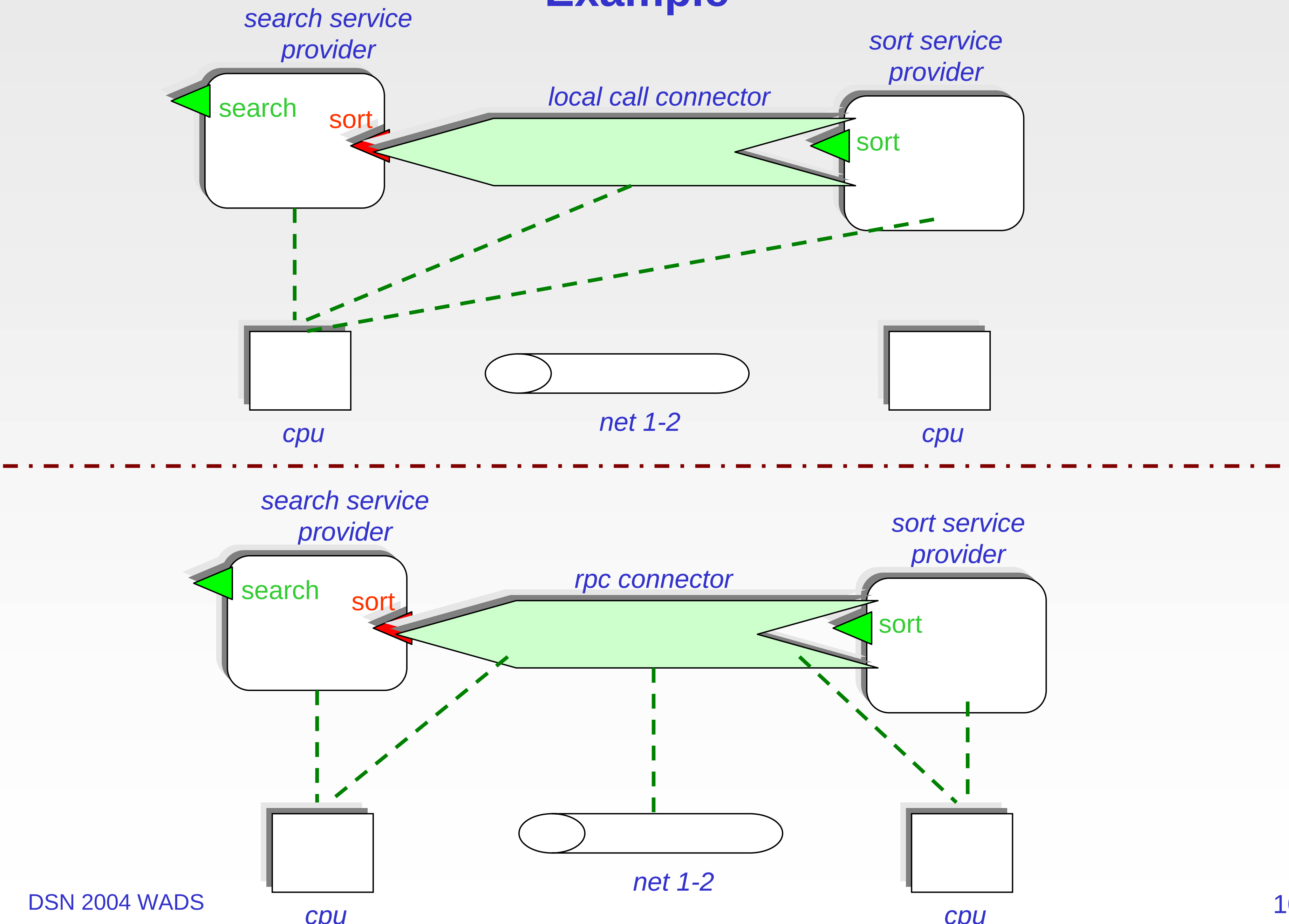
- Software Architecture and Component based approaches

- main features
  - the "interaction infrastructure" is a first class concept
    - *connector* concept
  - explicit consideration of dependencies between offered and required services
  - attention given to non functional (QoS) properties

  but …

  - several (too many?) "experimental" architecture description languages (ADLs)
    - some unification/interoperation effort
  - need of a better integration of QoS analysis techniques
    - non well defined “QoS semantics” for existing ADLs

# Example



search service provider
search
sort
local call connector
sort service provider
sort
cpu
net 1-2
cpu
search service provider
search
sort
rpc connector
sort service provider
sort
cpu
net 1-2
cpu

# Contributions from each area (3)

- QoS modeling and analysis

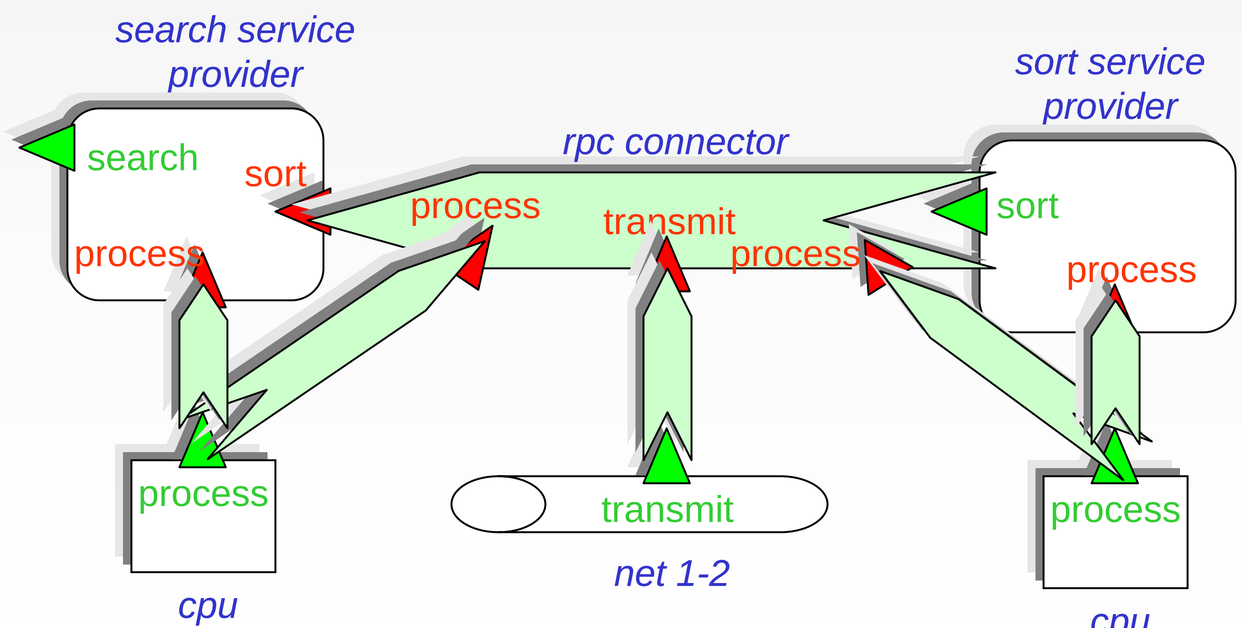
- main features
  - analysis techniques
  - QoS specification languages
    - QML (Frolund - Koistinen, 1998), HQML (Gu *et al.*, 2001), CQML (Aagedal, 2001), CQML+ (Rottger - Zschaler, 2003), …
    - UML QoS Profile

  but …

  - weak connection between QoS specification languages and QoS analysis techiques
  - unsatisfactory support for compositionality in existing QoS languages

# Integration of contributions (1)

- a **QoS language** for SOC
- built around a unifying “service+connector” model
  - for both “high level” and “low level” services
    - more flexibility
    - simpler description language definition



# Integration of contributions (2)

- “analytic interface” associated with each offered service
  - general concept proposed by CMU-SEI (PECT: Prediction Enabled Component Technlogy)
  - suitable abstraction of the “constructive (functional)  interface”
  - allows a structured approach to compositional analysis

- in our approach:
  - consider services offered by both resources (components) and connectors
  - “abstract” service representation
    - abstract service description
      - abstract parameter domains
    - (for non basic services) abstract service request flow addressed to other resources/connectors: stochastic model
      - abstract flow: probabilistic graph
      - abstract service request: actual parameters as (parametric) random variables

# Example (1)

- "abstract" service description :

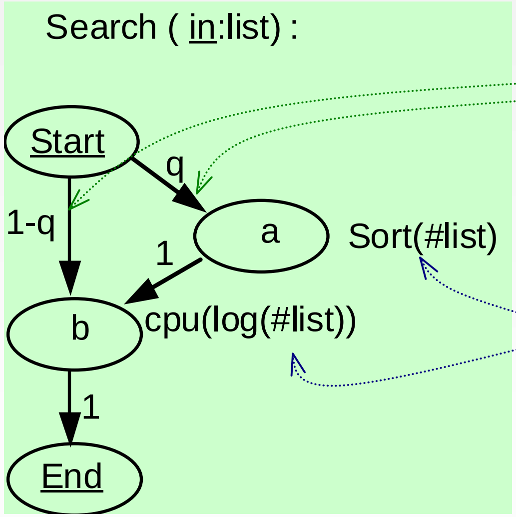
list size

Search(in i : T; in l : list of T; out res: boolean) → Search(l : integer)

"functional" description — abstraction

- "abstract" service request flow :

Search(in i : T; in l : list of T;
out res: boolean)
{if not_ordered(l)
then Sort(l);
res := do_search(i, l);
}



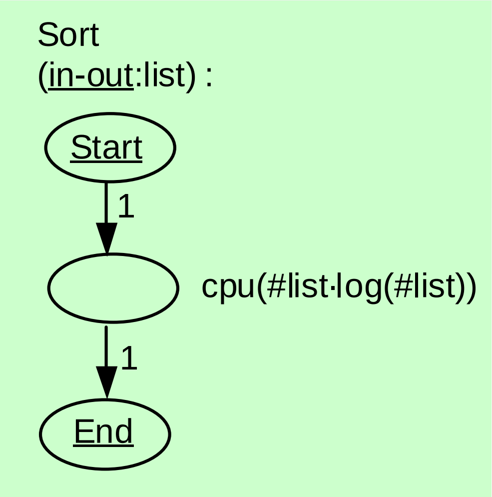

abstract flow

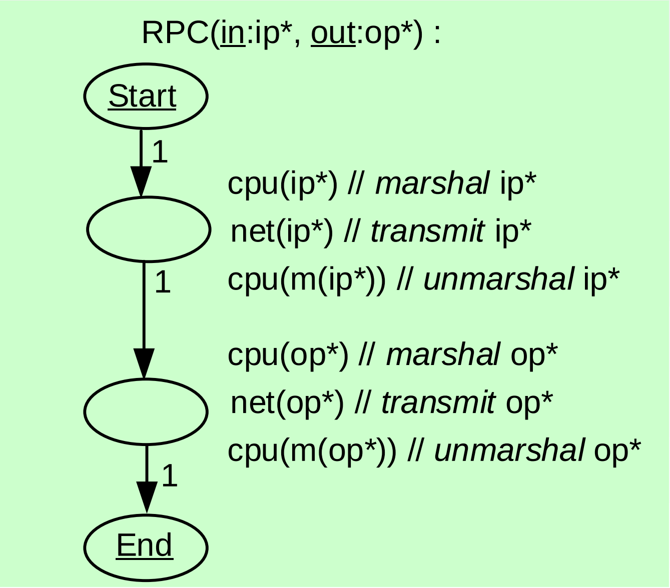
abstract service requests

"functional" description — abstraction

# Example (2)

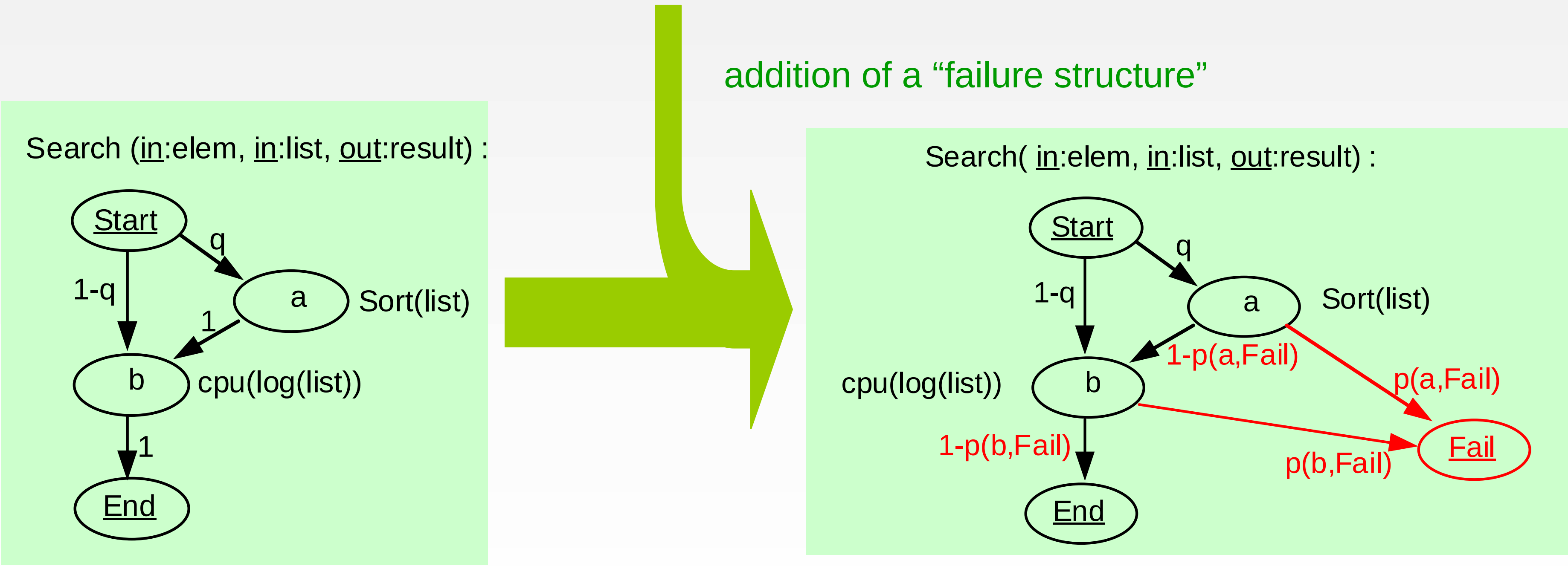
- abstract request flows of the Sort and RPC services



# Dependability prediction

- the presented concepts provides the support for QoS compositional prediction
- addition of QoS related information (specialized for some QoS dimension, e.g. dependability) with well defined semantics
  - example: composite service **reliability** analysis




- reliability = probability of reaching the End state
- crucial issue: evaluation of p(*node*, Fail)

# “Dependability semantics” issues (1)

- *node* of a service request flow graph: collection of service requests

  *node* = {R1, R2, …, R*n*}, where:

  R*j* = *request*(*Sj*, *apj**)    *Sj* = required service specification

  *apj** = list of actual (abstract) parameters

  *node* failure probability: depends on :

  - failure probability of each R*j*
  - completion model for R1, R2, …, R*n*
    - *AND*, *OR*, ...
  - dependencies among R1, R2, …, R*n*
    - no dependence (e.g. no service sharing), dependence (e.g. service sharing)

  failure probability of R*j* depends on :

  - *internal* failure prob for R*j* (*Pfail_int*(R*j*)) (definition?)
  - *connector* failure prob for R*j* (*Pfail_connect*(R*j*))
  - *service* failure prob for R*j* (*Pfail_service*(R*j*))

  *Pfail_int*(R*j*) × *Pfail_connect*(R*j*) × *Pfail_service*(R*j*) **?**

# "Dependability semantics" issues (2)

- R*i* = *request*(*Si*, *api**)
  R*j* = *request*(*Sj*, *apj**)
  - what if *Si* = *Sj* ? (i.e., the two requests are connected to the same service *S*)

- failure prob {R*i*} = *Pfail_int*(R*i*) × *Pfail_connect*(R*i*) × *Pfail_service*(R*i*) ?
  failure prob {R*j*} = *Pfail_int*(R*j*) × *Pfail_connect*(R*j*) × *Pfail_service*(R*j*) ?

OK

R*i* = *request*(*S*, *api**)   R*j* = *request*(*S*, *apj**)

flow graph node: *AND* completion model

NO

R*i* = *request*(*S*, *api**)   R*j* = *request*(*S*, *apj**)

flow graph node: *OR* completion model

# Conclusions

issues for dependability (QoS ) prediction in a SOC framework

- inclusion of a well structured "analytic interface" into existing XML-based service description and composition languages
  - based on concepts from Software Architecture approaches (connectors!)
- dependability (QoS ) semantics deserves special care
  - example: dependability analysis methodologies should not be based on *a priori* (prior to service composition) independence assumptions
    - service composition or F-T features can introduce dependencies among services
- reuse existing work on algorithmic methods for the automatic generation of QoS analysis models
  - mostly from UML models
  - idea: express the QoS semantics of XML-based SOC languages in terms of appropriate UML models
    - UML Profile for Modeling QoS and F-T