A Triple Space-Based Semantic Distributed Middleware for IoT

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Presentation

Motivation

- Self-configuring wireless network of devices whose purpose would be to interconnect all things
- Smart environments usually consist of a central device which has reason capacity and coordinates other devices
- Requires human intervention every time a new device is deployed
- Our aim is try to simplify the collaboration between devices
  - providing certain *intelligence* on them
  - without centralized coordinator

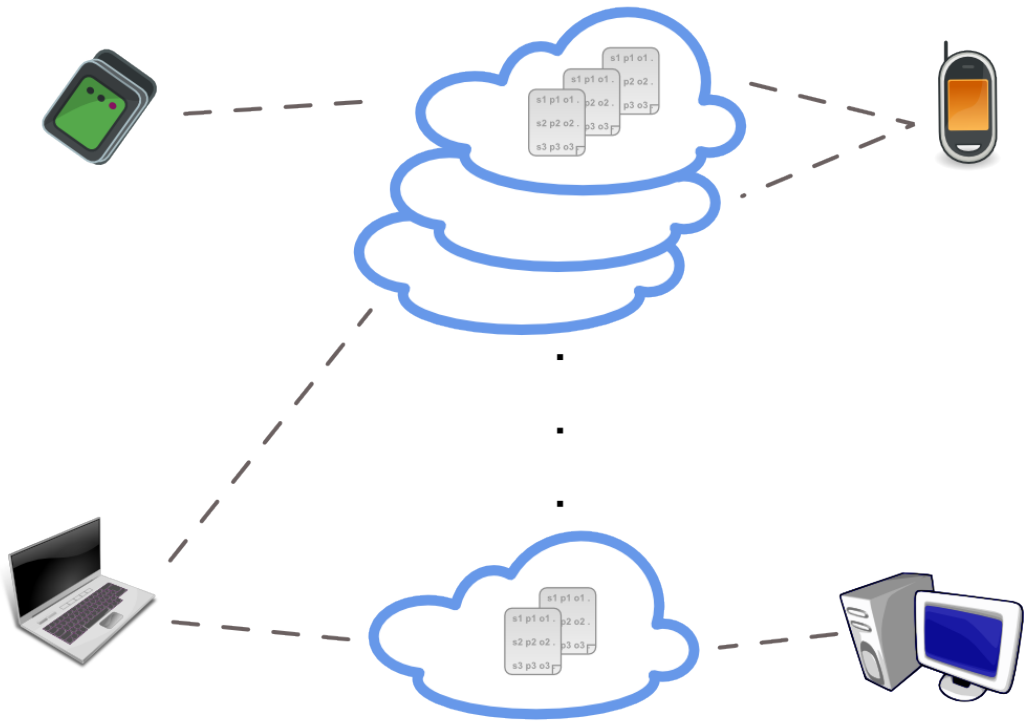
Some alternatives...

- UPnP. Autoconfigure networks, devices share capabilities, events...
- DLNA. To share media content.
- Drawbacks:
  - Multiple APIs and protocols from different vendors
  - Semantic: Share knowledge instead of data.
  - Without predefined language.

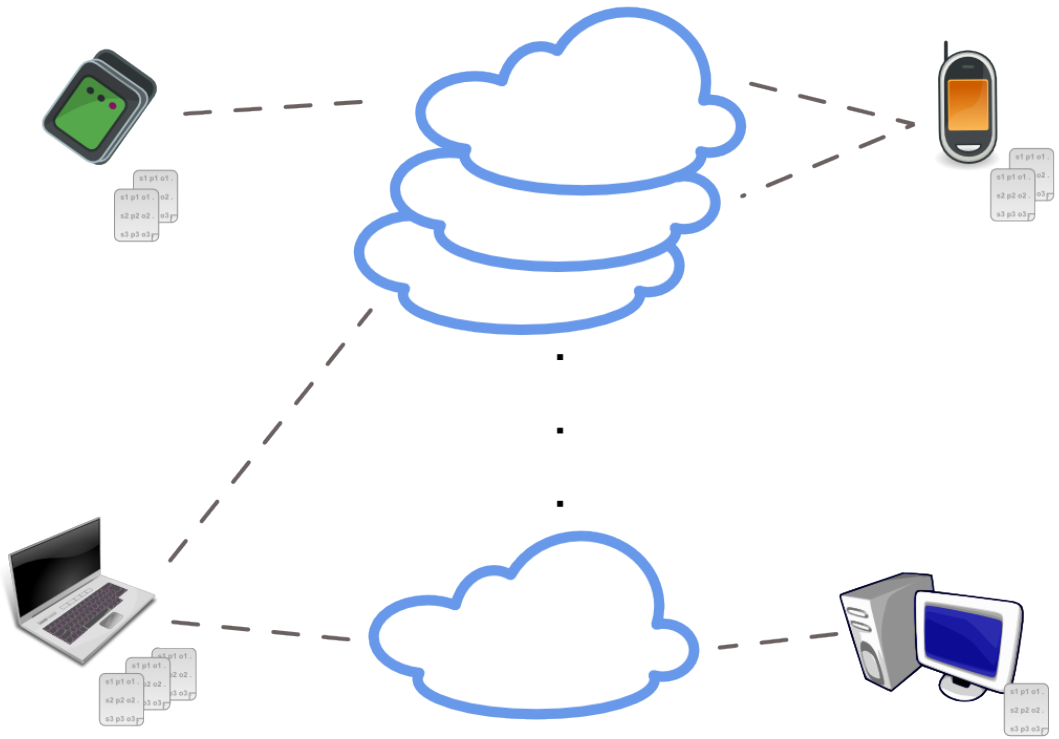
Triple Space

- Tuplespace: read and write data structures in a shared space
- TripleSpace: read and write triples of semantic data
  - Reference autonomy
  - Time autonomy
  - Space autonomy
- tsc++

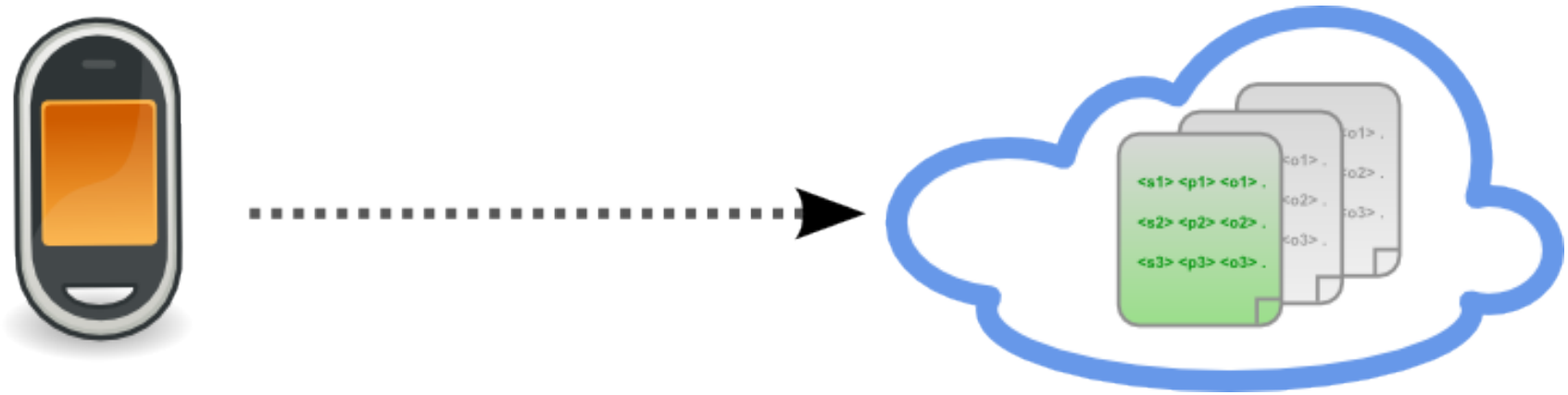
Distributed approach



How is it distributed?

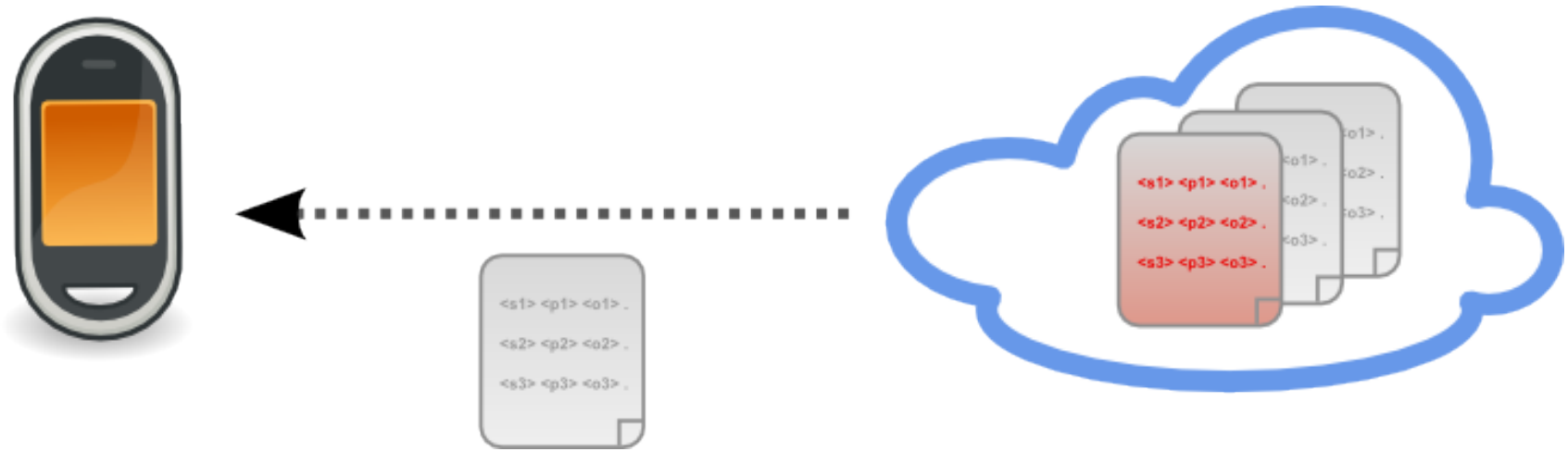


Write

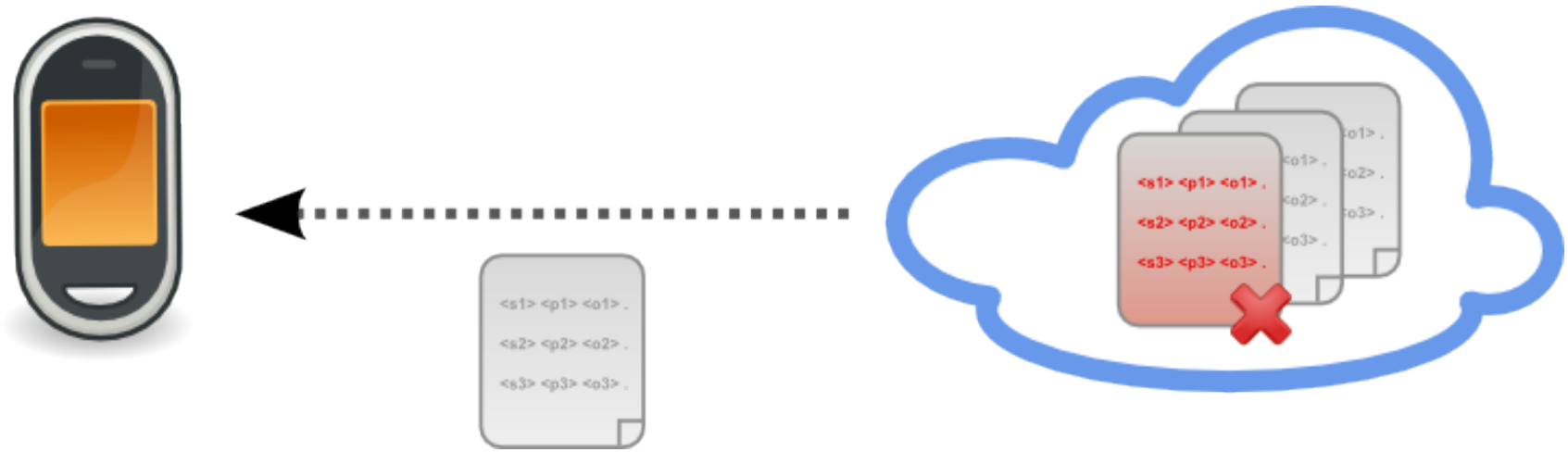


Query

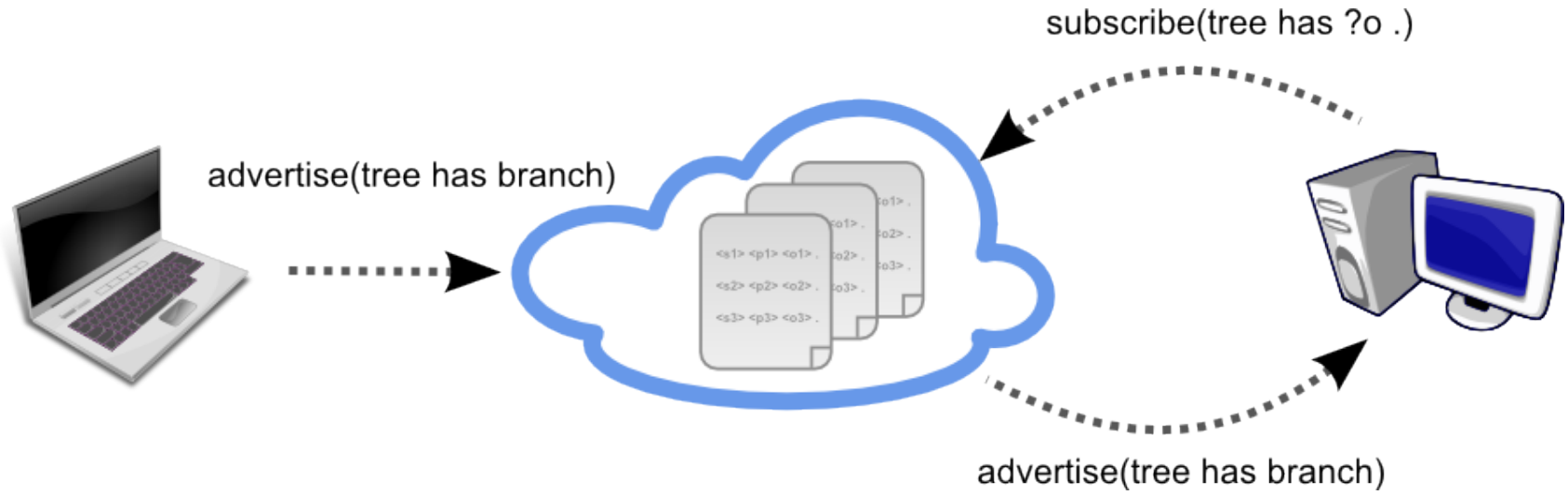
Read



Take



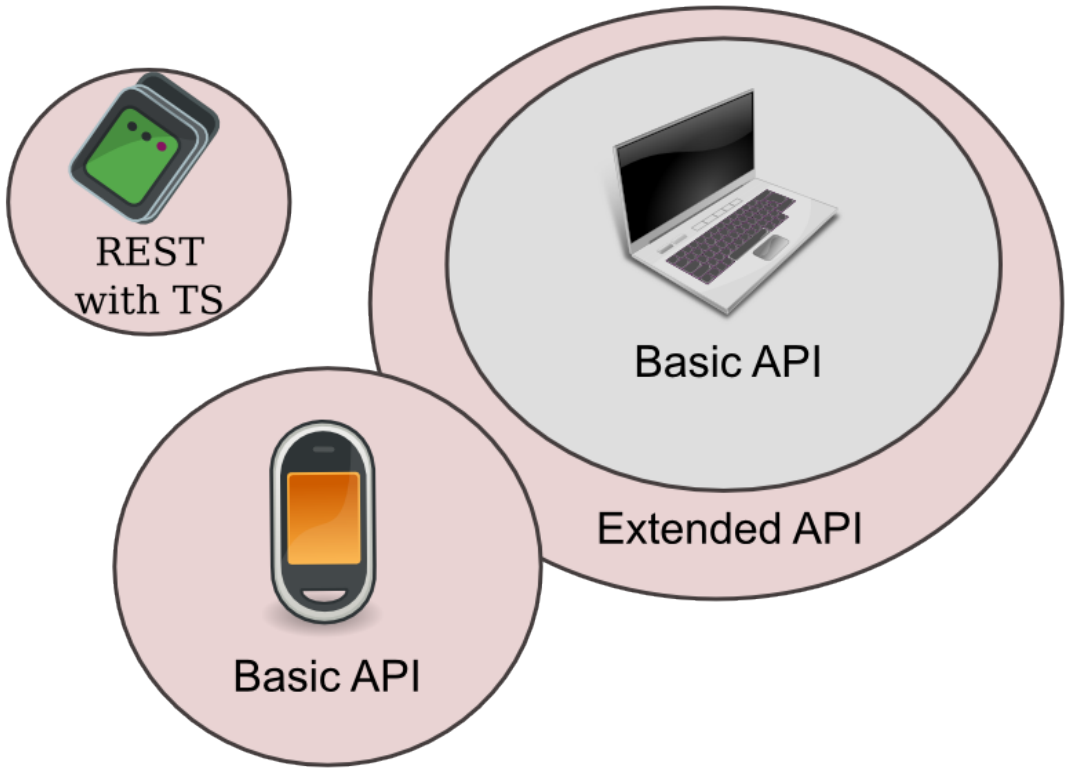
Subscribe and advertise



Proposed middleware

- tsc++ has been modified to provide another 3 primitives
  - queryMultiple
  - register
  - invoke
- tscME developed
- communication between tsc++ peers and tscME peers
- gateway for other embedded devices

Boundaries



Query vs. QueryMultiple

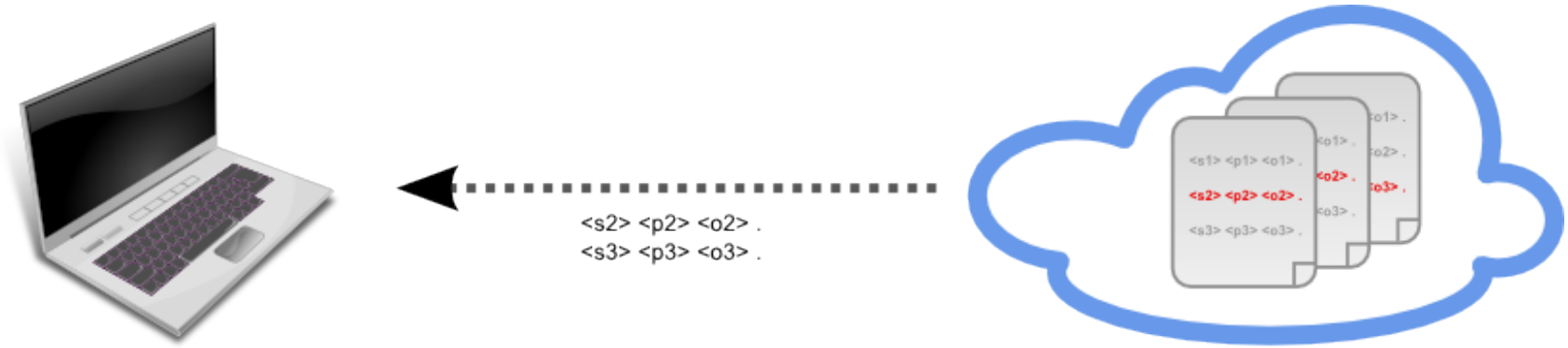
- template: ?s ?p ?o .
- n templates which are extracted from a SPARQL query

Input query

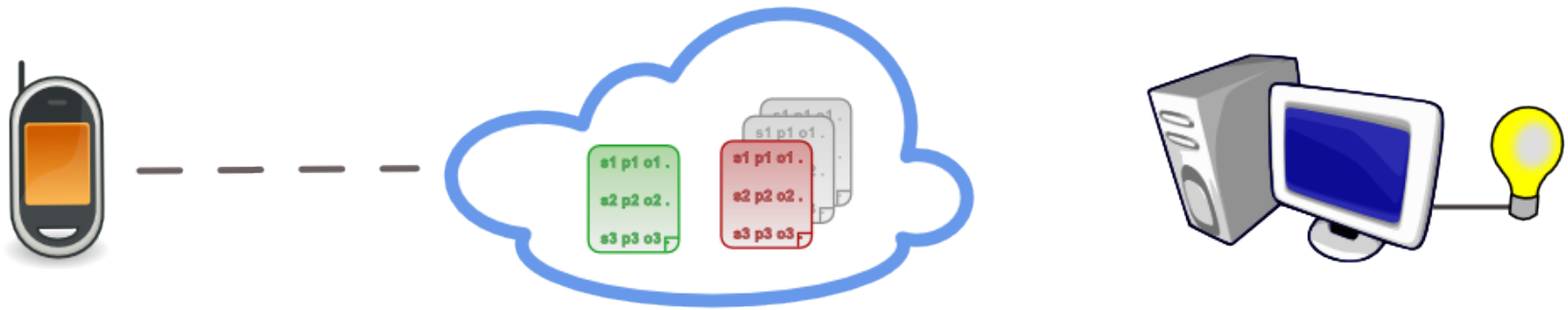
```
CONSTRUCT {
  ?measure ismed:hasValue ?value .
}
WHERE {
  ?measure rdf:type ismed:LightMeasure .
  ?measure ismed:hasValue ?value .
  ?measure ismed:hasDateTime ?datetime .
  OPTIONAL {
    ?measure2 rdf:type ismed:LightMeasure .
    ?measure2 ismed:hasDateTime ?datetime2 .
    FILTER(?datetime2 > ?datetime) .
  }
  FILTER( !bound(?datetime2) )
}
```

Templates after processing the query

- ?s rdf:type ismed:LightMeasure .
- ?s ismed:hasValue ?o .
- ?s ismed:hasDateTime ?o .



Why is a new service approach necessary?

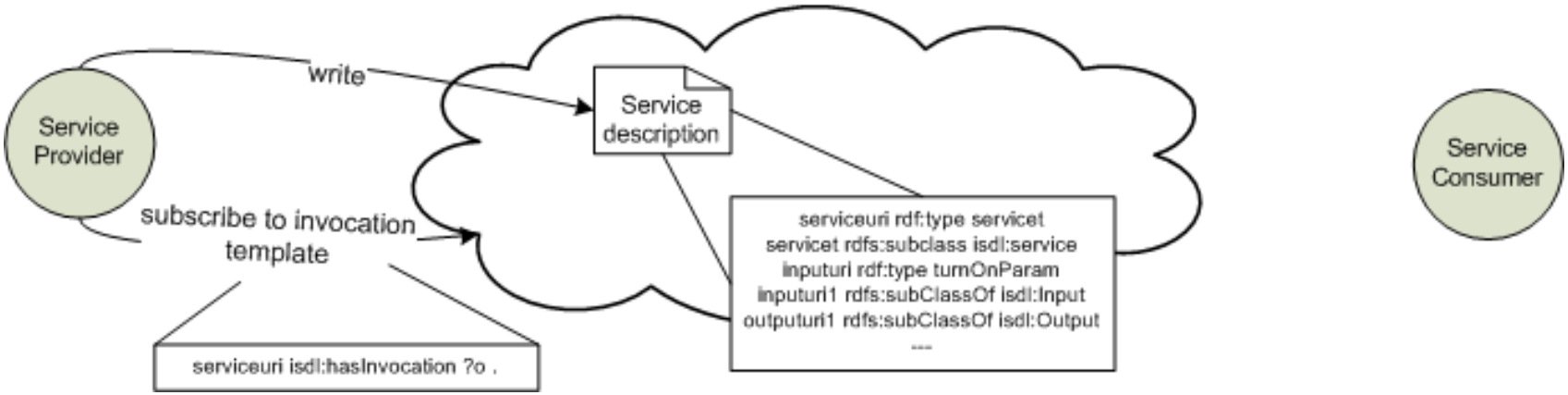


Security

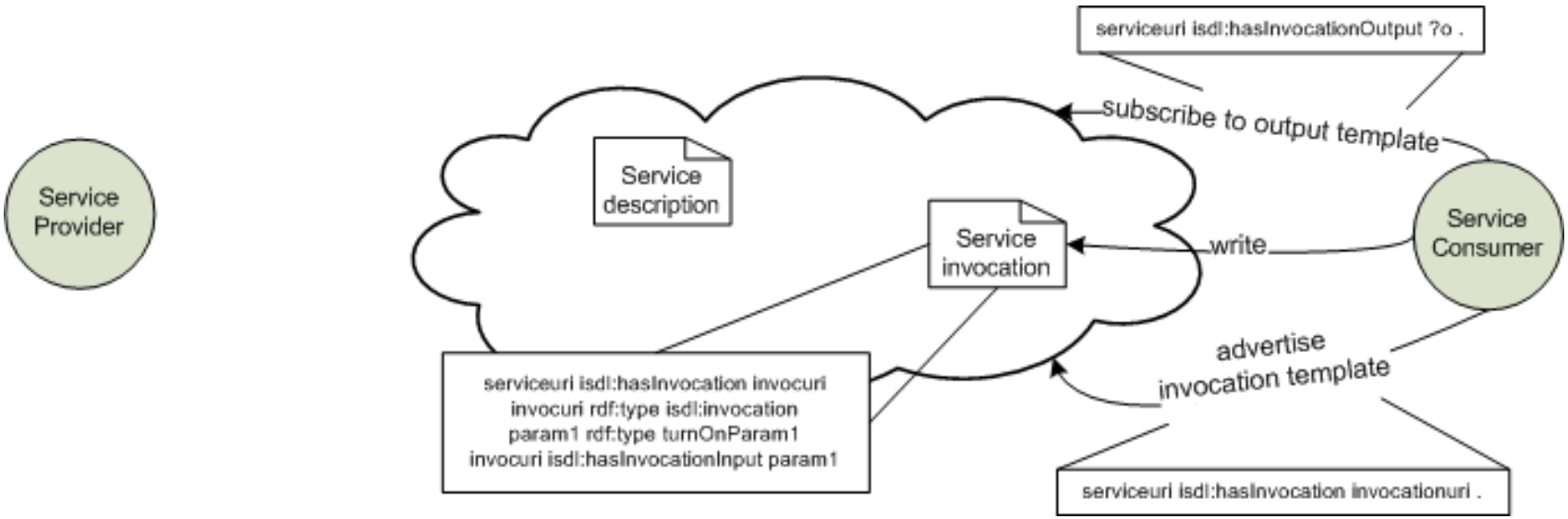
Concurrency

Location of the information

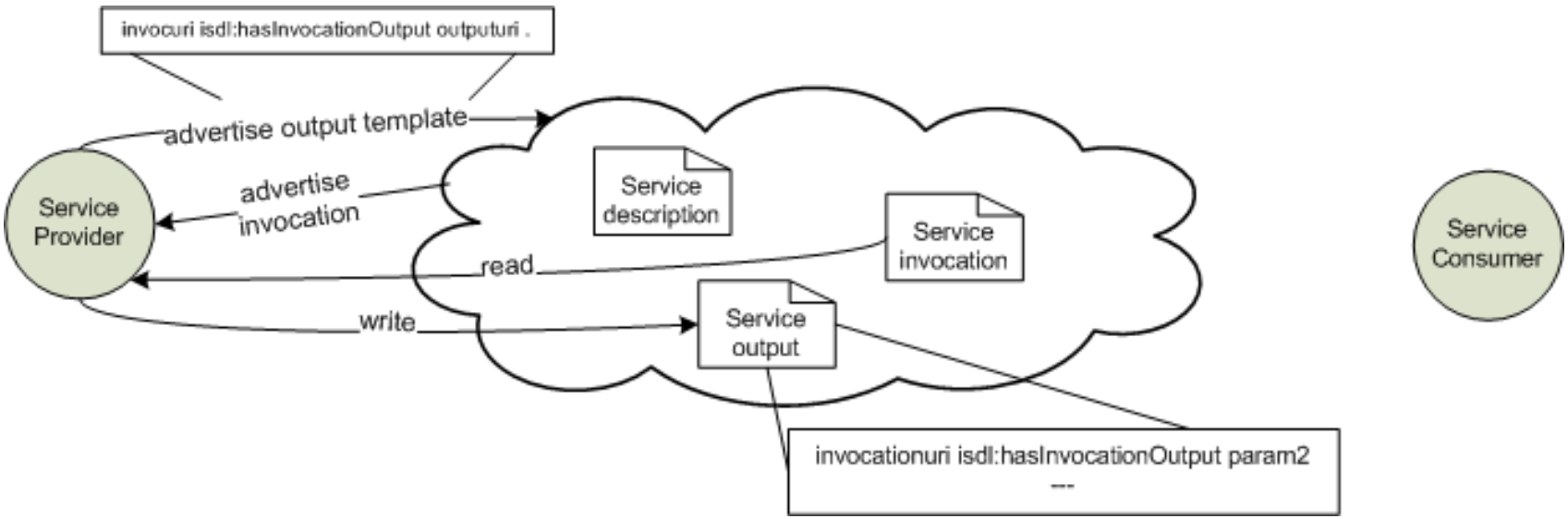
Register


write
Service Provider
Service description
subscribe to invocation template
serviceuri isdl:hasInvocation ?o .
serviceuri rdf:type servicet
servicet rdfs:subclass isdl:service
inputuri rdf:type turnOnParam
inputuri1 rdfs:subClassOf isdl:Input
outputuri1 rdfs:subClassOf isdl:Output
...
Service Consumer

Invocation (from the service consumer point of view)

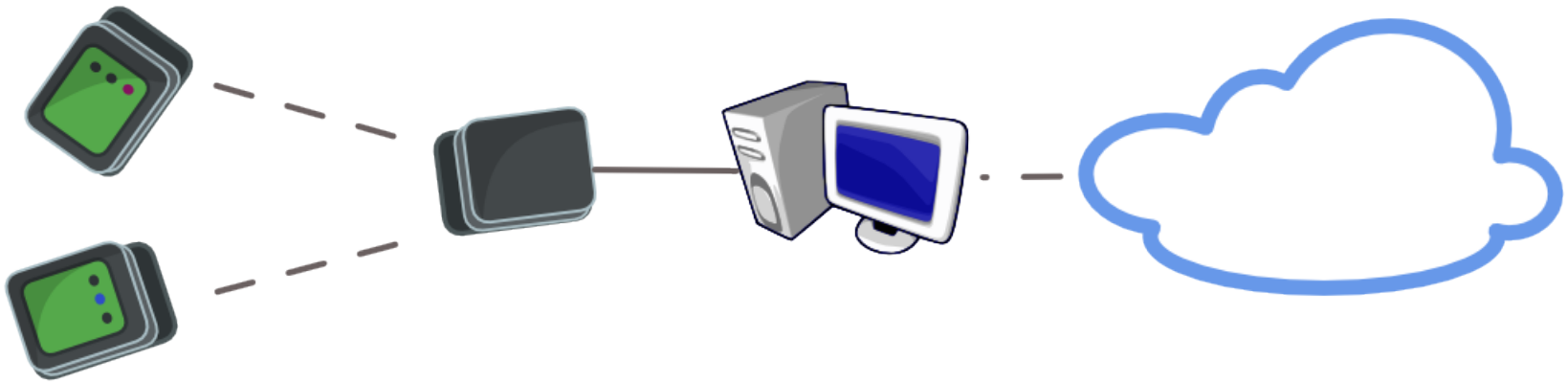


Invocation (from the service provider point of view)



Embedded platform: SunSPOT

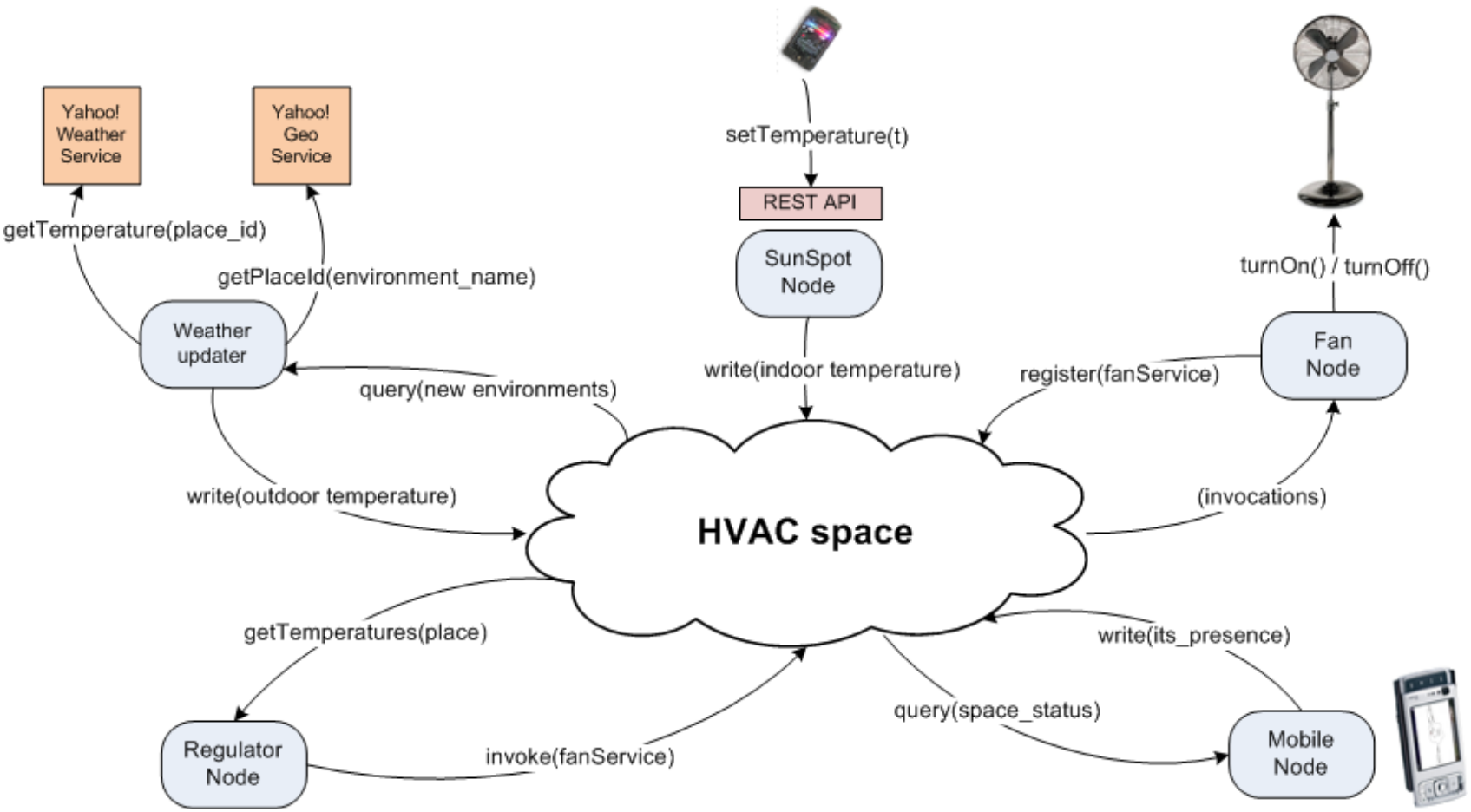
- Squawk Virtual Machine
- Basestation
- RESTful API for tsc++: Jetty + Jersey



Mobile platform: tscME

- Communication: Jxme
- Data store: RecordStore/Memory
- Semantic mngmnt: Microjena

Scenario


Yahoo! Weather Service
Yahoo! Geo Service
getTemperature(place_id)
getPlaceId(environment_name)
Weather updater
query(new environments)
write(outdoor temperature)
setTemperature(t)
REST API
SunSpot Node
write(indoor temperature)
turnOn() / turnOff()
Fan Node
register(fanService)
(invocations)
HVAC space
getTemperatures(place)
Regulator Node
invoke(fanService)
write(its_presence)
query(space_status)
Mobile Node

Experimentation

Kernels	1			10			20		
Spaces	1	5	10	1	5	10	1	5	10
read	0.2	0.2	0.3	3.5	3.0	3.0	10	10	9.8
take	0.2	0.2	0.3	3.4	2.9	2.6	10.3	9.9	11.1
query	0.4	0.3	0.2	7.0	3.7	3.3	24.8	11.9	10.6

Table: TscME networking evaluation results (in seconds)

- ↑ responses: ↑ processing time
  - perform specific queries
- ↑ graphs: ↑ processing time
  - distribute graphs over different spaces

Conclusions

- TS appropriate to share knowledge between heterogeneous devices
- tsc++ is not appropriate for mobile devices: tscME
- Primitives are powerful but awkward
- Performance dependent on the implementation
- Not only between them, also exporting data to Internet