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A Scalable Cloud Storage for Sensor Networks

Gérôme Bovet[1, 2] – Gautier Briard[3] – Jean Hennebert[2]

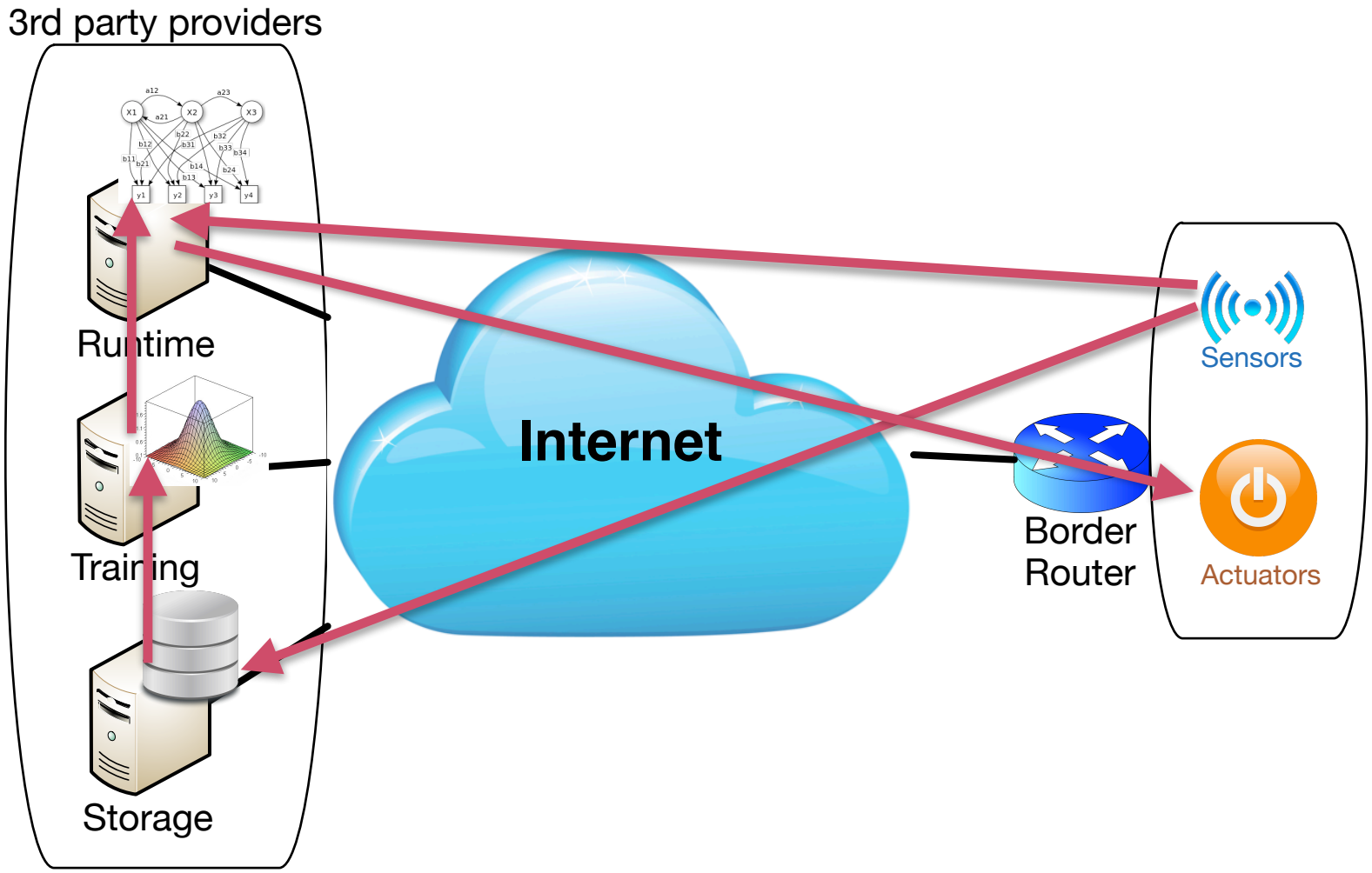
[1]Telecom ParisTech France

[2]University of Applied Sciences Western Switzerland

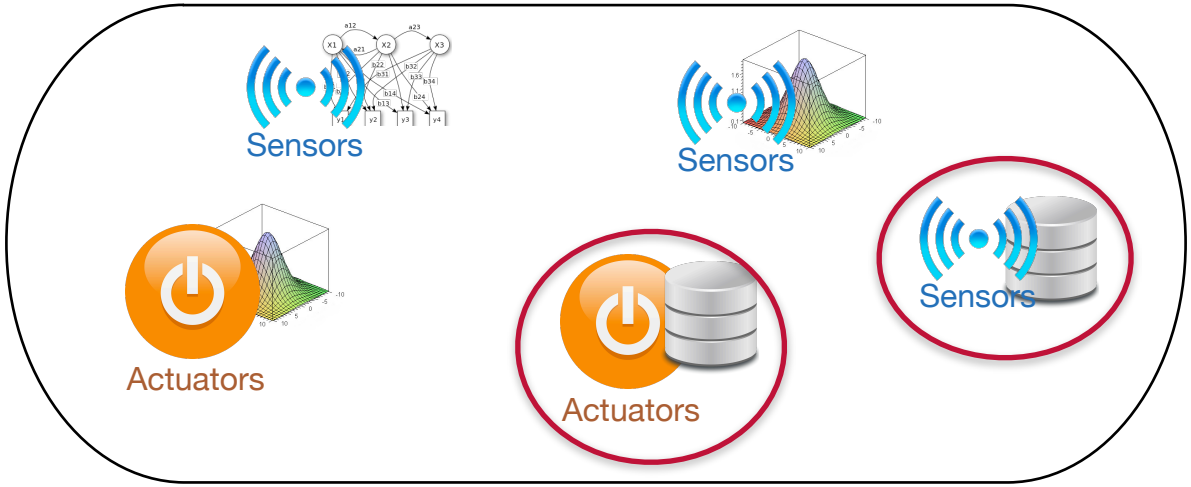
[3]University of Belfort-Montbéliard France

gerome.bovet@hefr.ch

Introduction



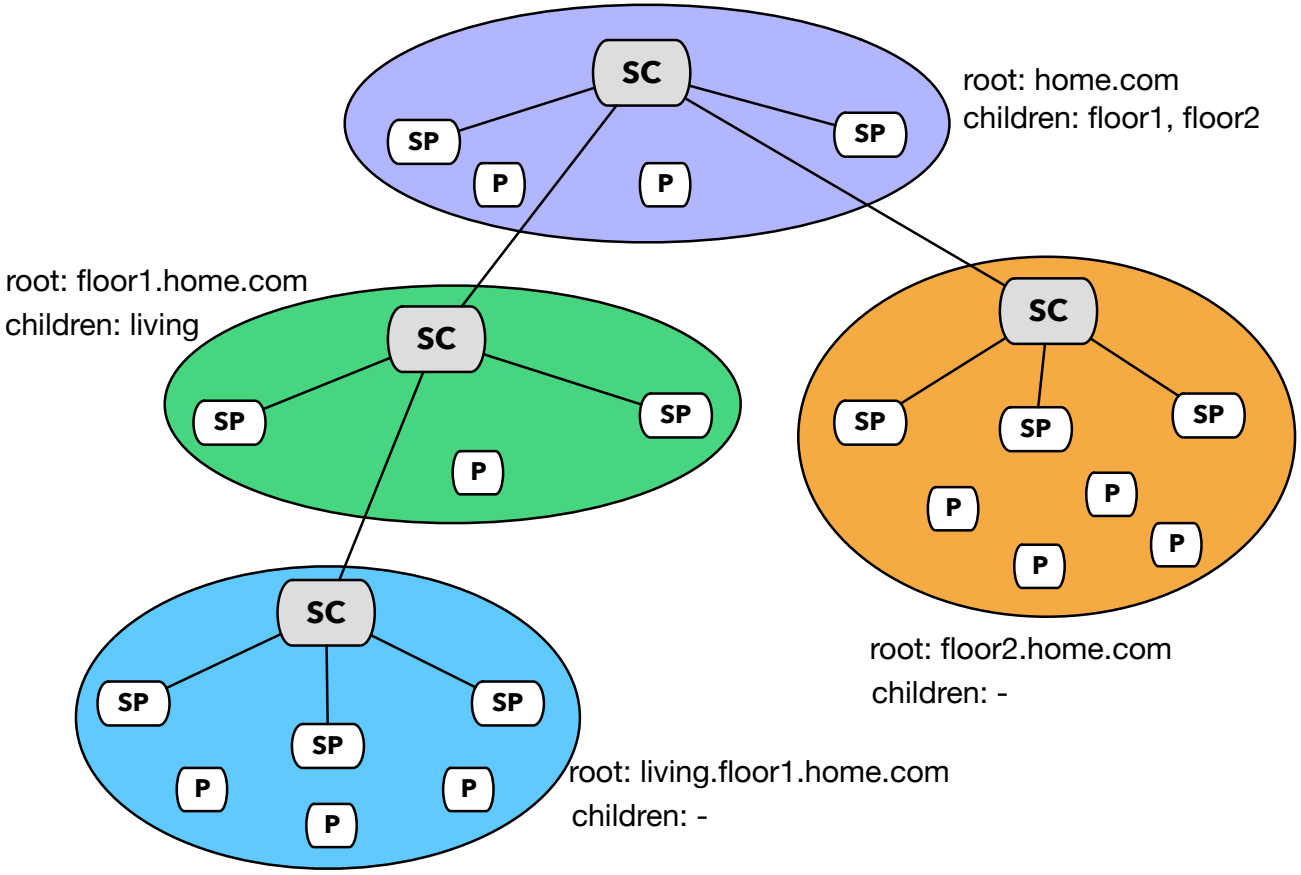
Introduction



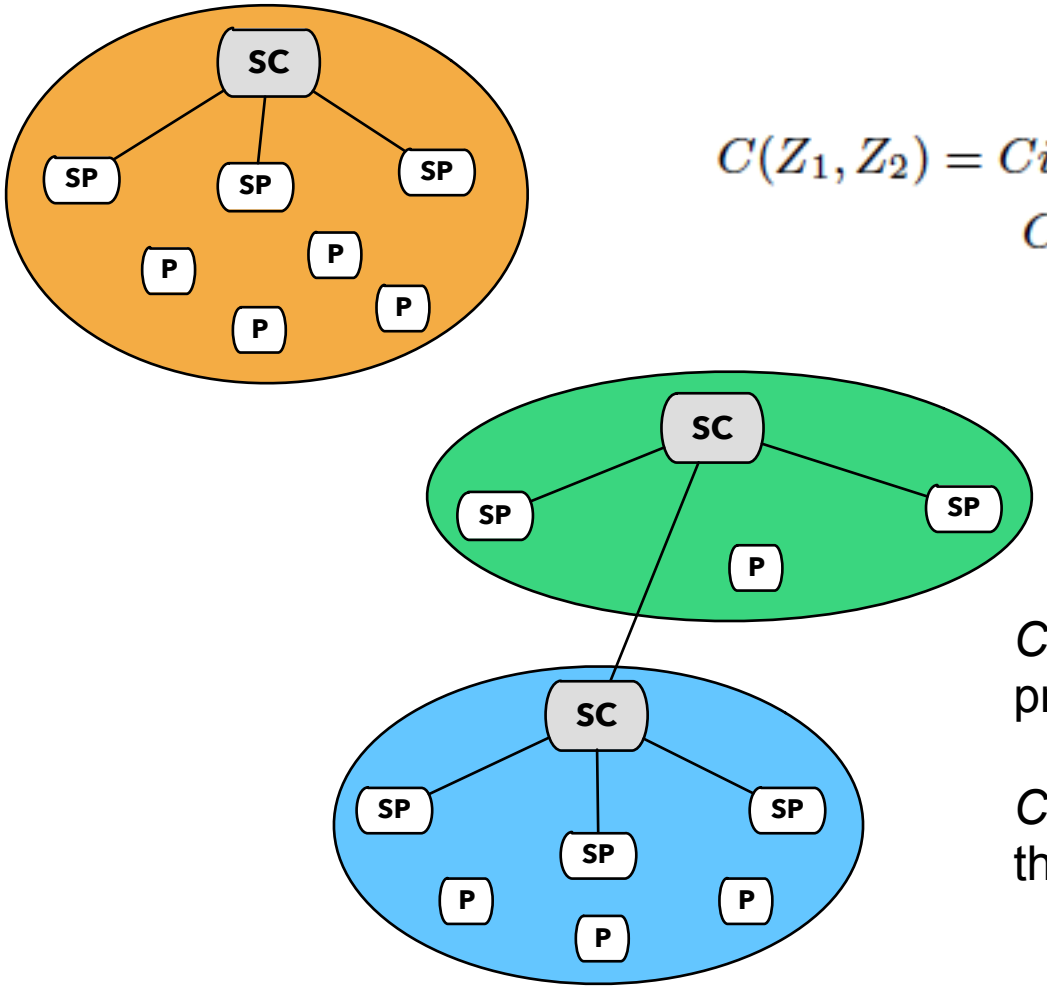
- **Autonomous and self-sufficient networks**
- **Training phase requires access to historical data**
- **Limit network traffic and augment data availability where it is used**

Zones

- **Build zones according to the building structure**
  - Do the training where data is produced



Zones - Splitting

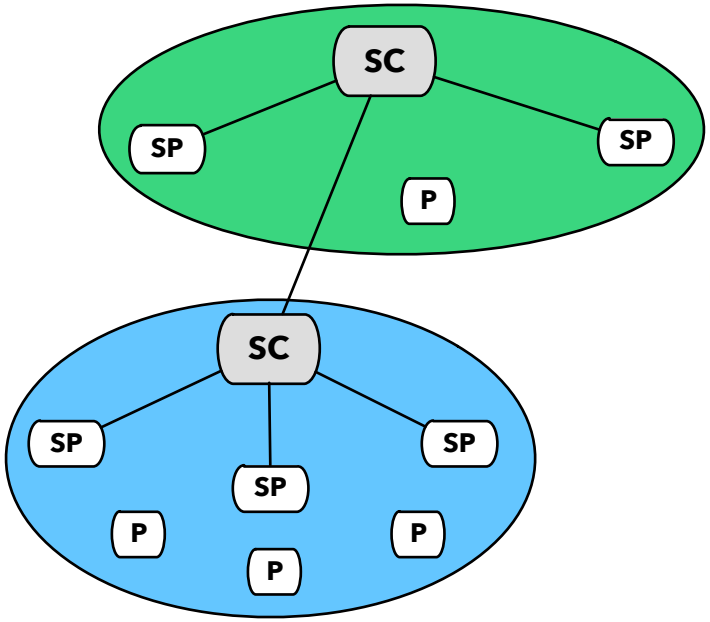


$$C(Z_1, Z_2) = Ci(Z_1) + Ci(Z_2) + Ce(Z_1, Z_2)$$
$$Ci(Z) - \min(C(Z_1, Z_2)) > \epsilon_s$$

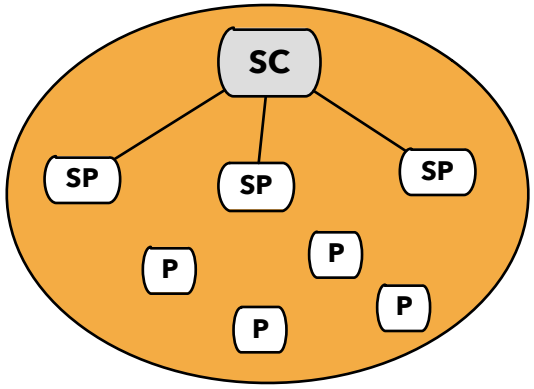
Ci: Total number of hops between producers and storage peers

Ce: Inter-zone costs depending on the filling rate of the child zone

Zones - Merging



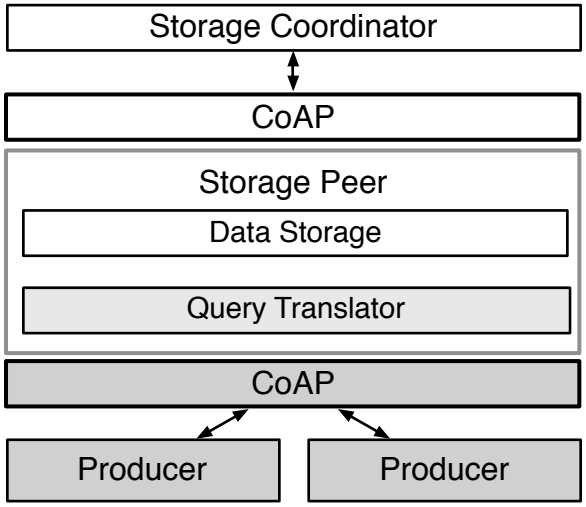
$$Cp(Z) = (Ci(Z_1) + Ci(Z_2)) * \ln(D(Z_1) + D(Z_2))$$
$$C(Z1, Z2) - Cp(Z) > \epsilon_m$$



D: Depth of a zone's internal locations tree

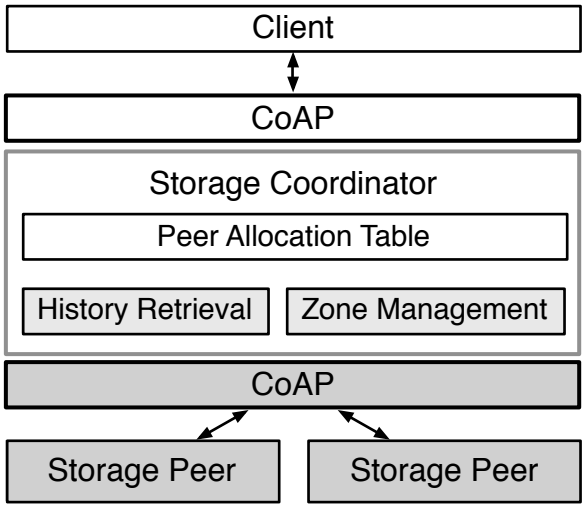
Entities - Storage Peers

- **Act as small databases for time-series**
- **Offer a RESTful interface hiding the internal storage technology (DBMS)**
  - Creating/deleting datasets
  - Inserting/reading data
- **Data insertion realized through multicast notifications of producers**



Entities - Storage Coordinators

- **Are managing a specific zone**
- **Decide whenever their zone should be split or merged**
- **Organize the repartition of data between storage peers**

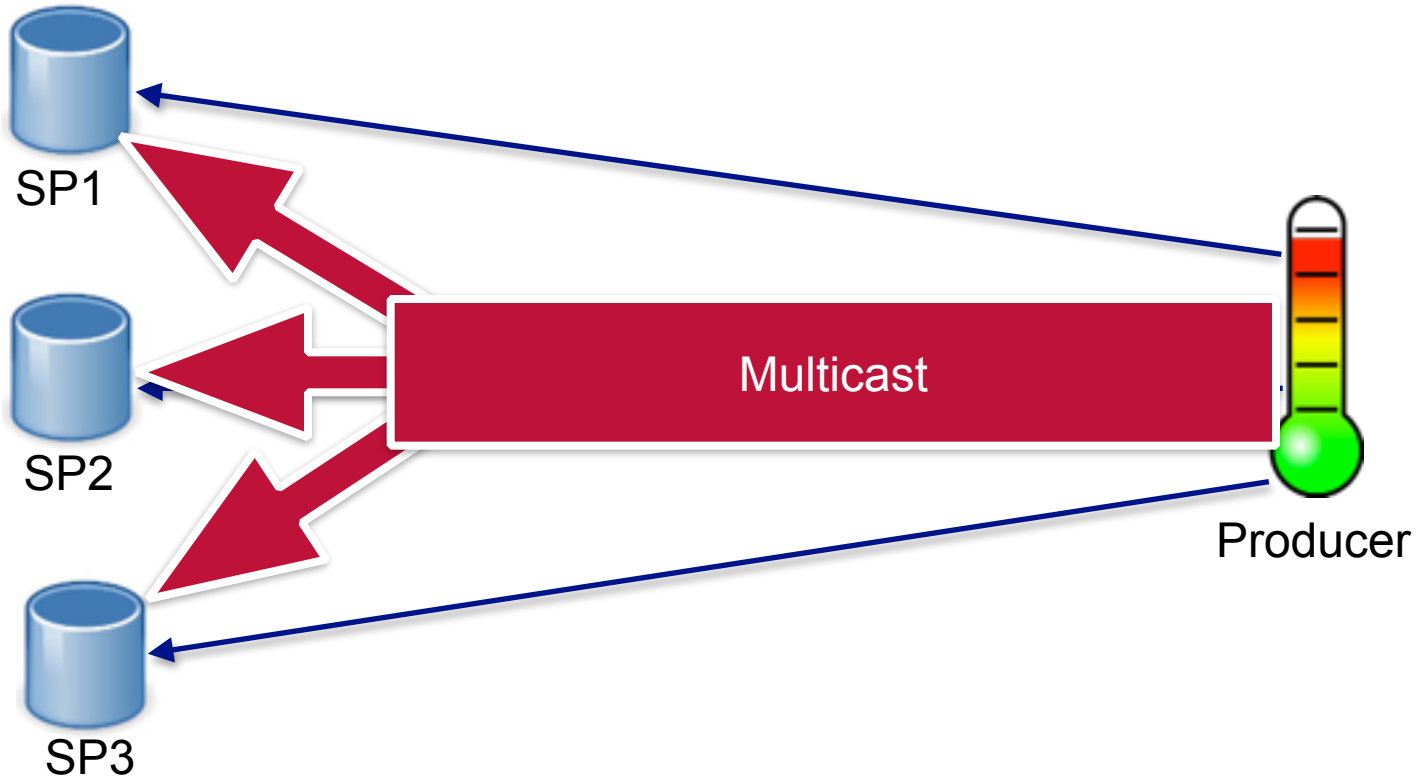


- **Offer a RESTful interface for retrieving stored data on peers**
  - Select the appropriate peers
  - Assemble the data

Interfaces

- **General management interface (common multicast)**
  - Used for discovering zones
- **Zone interface (zone specific multicast)**
  - Inter-zone communications
  - Data storage announcement
  - Data retrieval
- **Server interface (unicast)**
  - Synchronization between master and slave storage coordinators

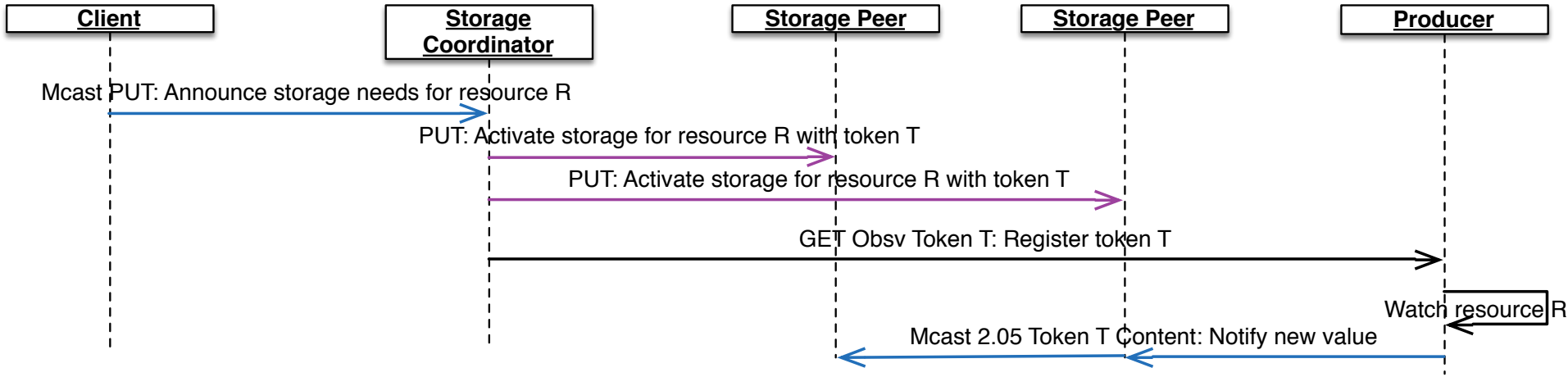
Storing sensor data



- **Ensure replication on several databases**
  - Unicast is inefficient

Storing sensor data

- **CoAP observe and groupcomm are mutually exclusive**
- **Improvements of CoAP**
  - Dynamically create multicast endpoints (token and multicast address)
  - Activate observation (multicast address)
  - Send notifications to multicast address
- **No reliability possible**



CoAP multicast observation

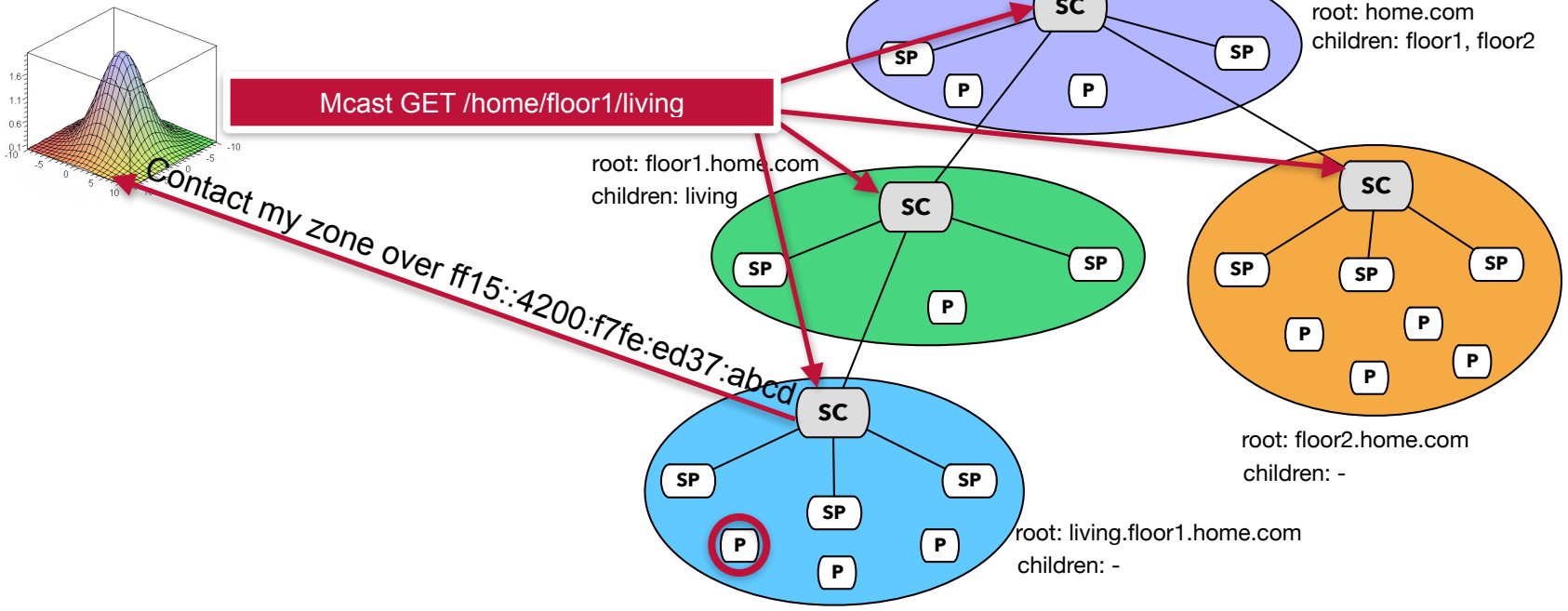
- **Combine observation and group communication**

- **Membership creation (from CoAP groupcomm)**

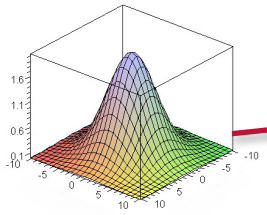
```
POST /{+gp}
{ "n": "All-
Devices.floor1.west.bldg6.example.com",
"a": "[ff15::4200:f7fe:ed37:abcd]:4567",
"t":1234}
```

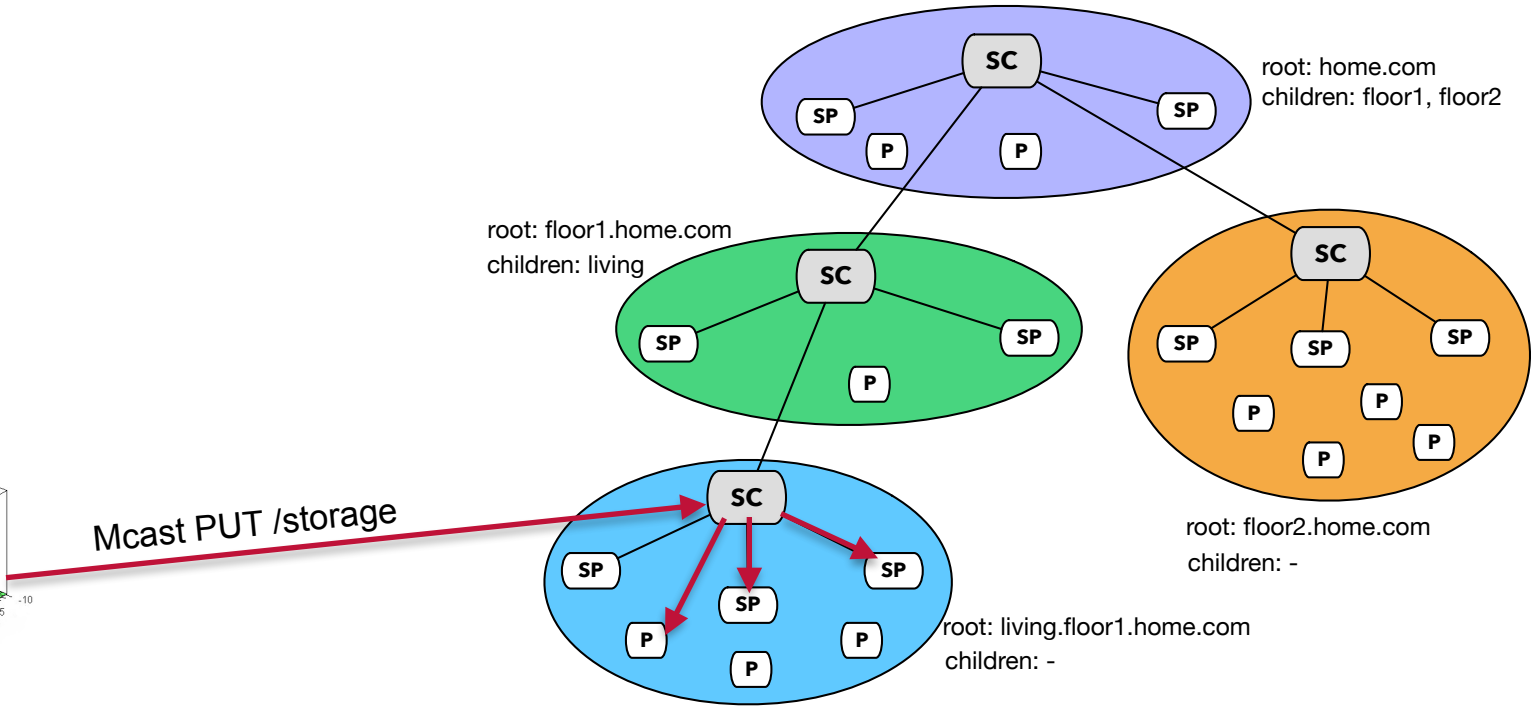
- **Observation**
  - Use same token as for membership creation (t)
  - Add option **Mcast-obsv** containing the multicast address (a)

Usage - Zone discovery



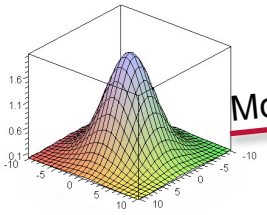
Usage - Data storage announcement

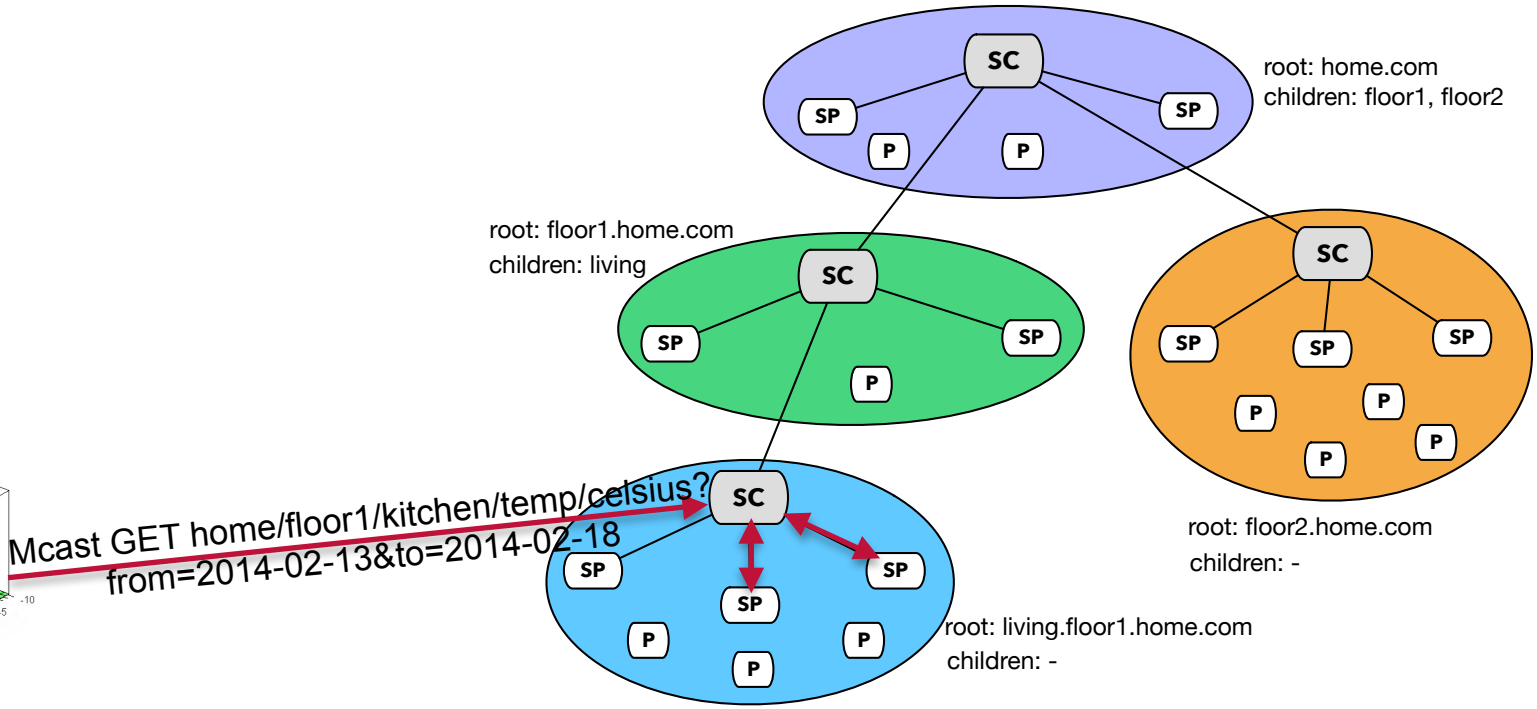





```
{
   "url": "temp.living.floor1.home.com/celsius",
   "max-age": 90,
   "unit": "day"}
}
```

Usage - Data retrieval

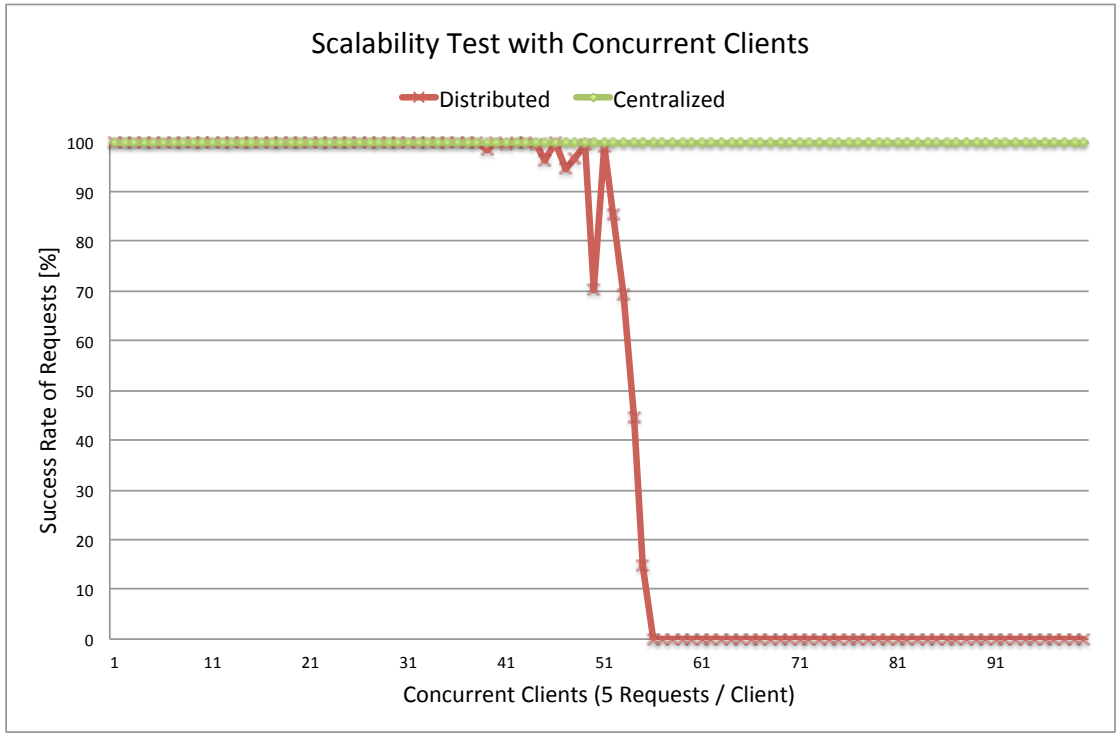





```
[{"timestamp": "2014-02-13 13:54:01",
  "value": 21.7},
  …
]
```

Evaluation

- **3 rooms over 2 floors as testbed**
  - 21 KNX and EnOcean sensors producing data
  - 8 Flyport OpenPicus as storage peers
  - 4 Raspberry Pies as storage coordinators



Each request returning **49** entries
Average **186 ms** pro request

Contributions

- **Location-based zone management**
  - Store data where it is needed
  - Efficient communications
- **Entirely anonymous communications with multicast**
  - Ensure availability
  - Insensitive to disturbances (storage coordinators)
- **CoAP adaptations for multicast notifications**
  - Becoming a draft?

Conclusion

- **Extensible-cloud like storage**
  - Add devices for extending the capacity
  - Adapted for machine learning applications
- **Self adaptation according to required storage space**
- **Easy to use RESTful interfaces for retrieving time-series**
- **CoAP multicast notifications very useful**
  - Need for standardization

Questions