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Department of Informatics
Technical University of Munich

A Management Framework for Secure Multiparty Computation in Dynamic Environments

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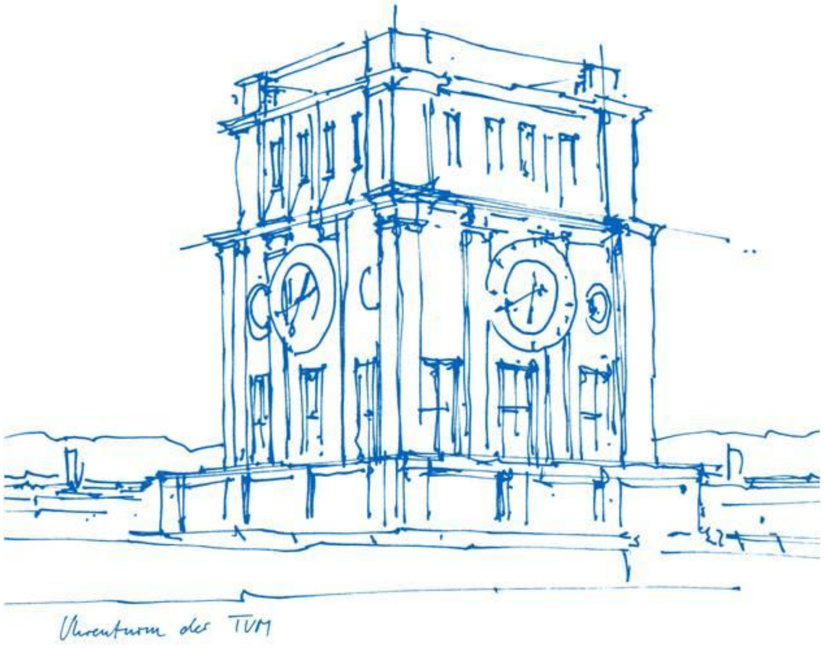

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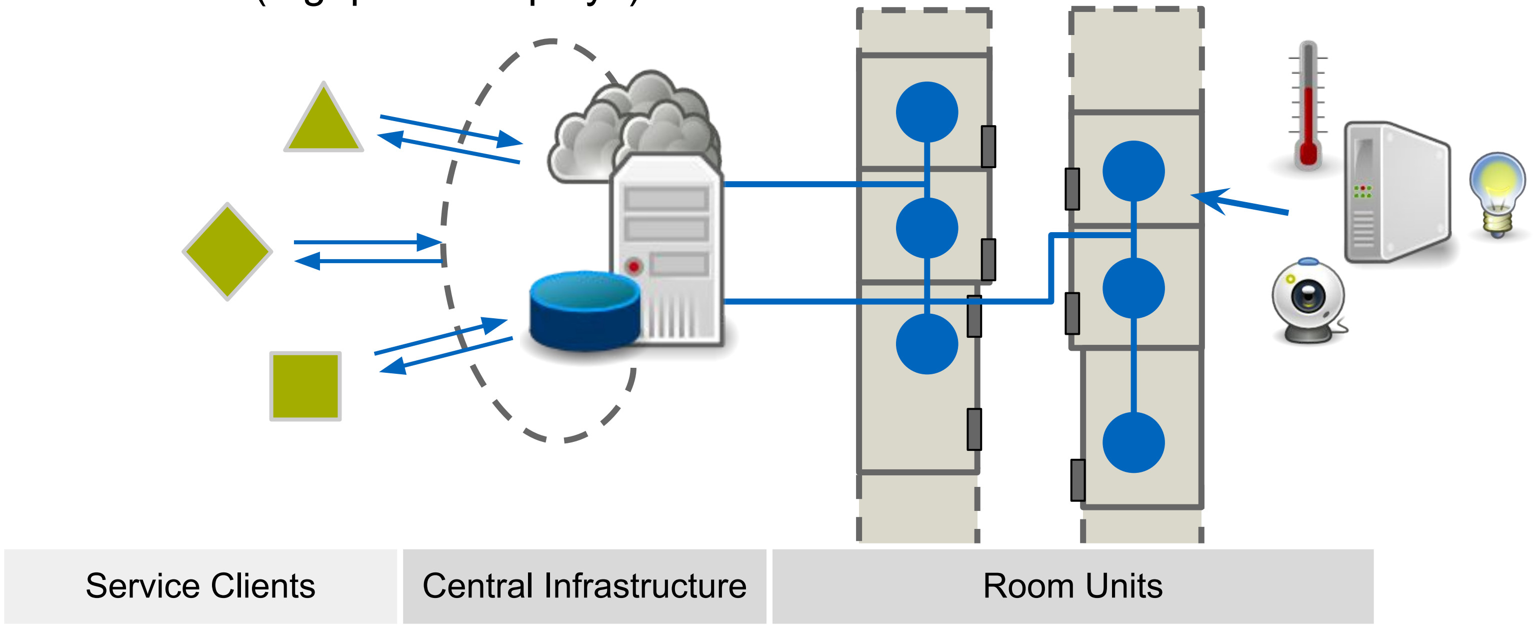
Outline

Motivation

Smart Environments are equipped with a variety of sensors in each room

A common use case is providing aggregated sensor and user data to

- support automatic controllers (e.g. HVAC and lighting)
- enable interaction interfaces (e.g. voting-based room configuration)
- inform users (e.g. public displays)

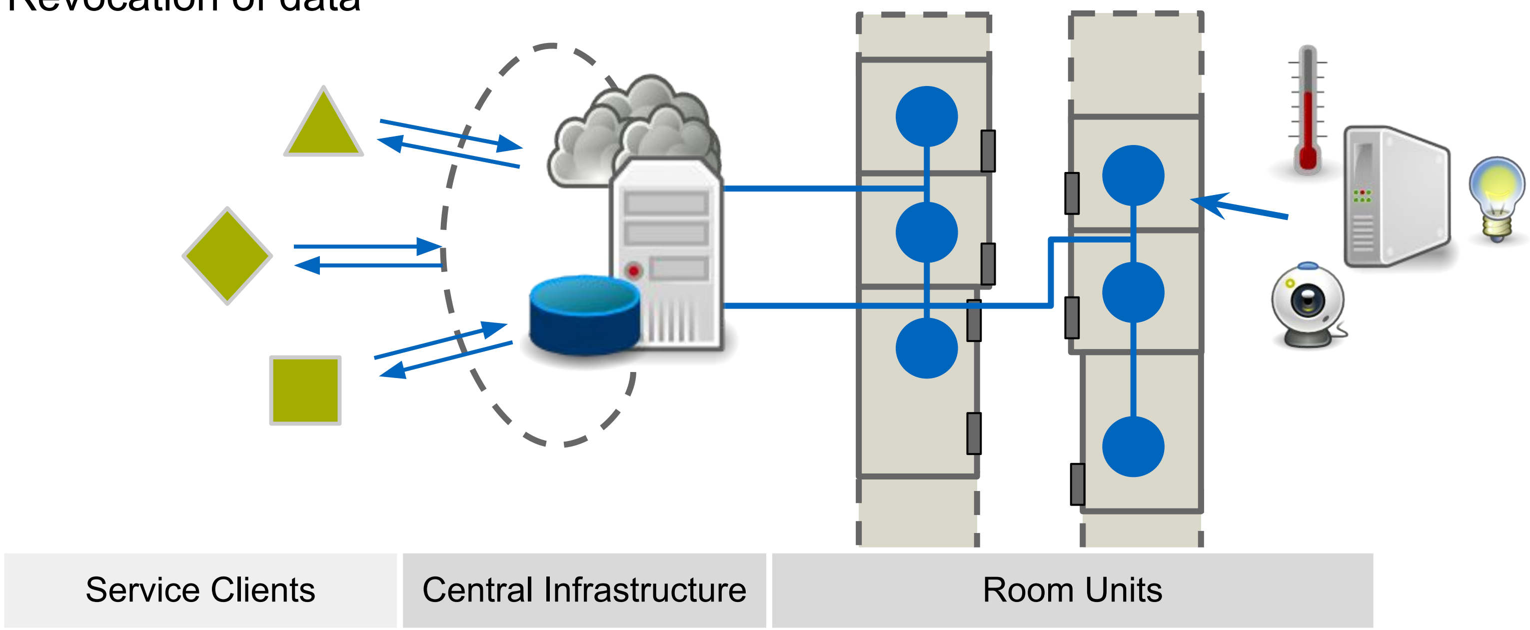


Problems

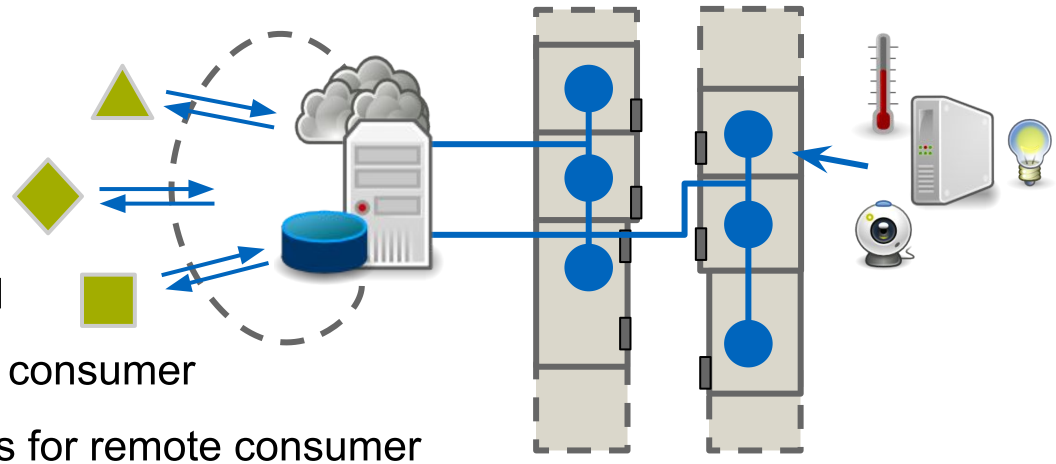
Central Infrastructure = Trusted Third Party

Conflicts with Privacy Requirements:

- Raw data accessible by TTP
- Data usage intransparent
- Revocation of data



Modelling



- Data gathering initially decentralized
- Data owner ≠ data processor ≠ data consumer
- Data usage: Aggregated local values for remote consumer
- Individual data more critical than aggregates
- Privacy [1-6] means
  - Data minimization
  - Unlinkability / Purpose binding
  - Transparency / Usage insights
  - Intervenability / Control over own data

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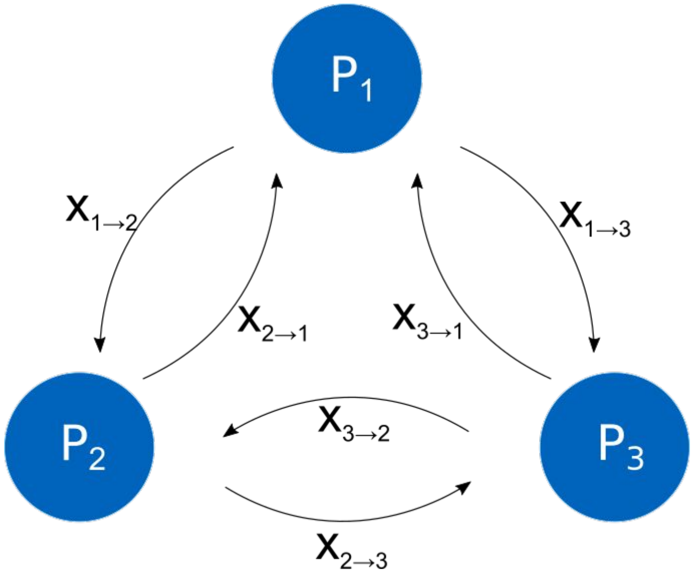
Background: Secure Multi-Party Computation

Definition (cf. [7]):
There are n parties $P_1, \ldots, P_n$. Each party P_i holds a secret value x_i.
Secure Computation of $y = f(x_1, \ldots, x_n)$ is performed if two conditions are satisfied:

- Correctness: the correct value of y is computed
- Privacy: y is the only new information that is released



Example: Addition

Party	x_i	Share P_1	Share P_2	Share P_3
P_1	10	3	2	5
P_2	5	1	2	2
P_3	7	4	1	2
Result	22	8	5	9

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From TTP to SMC: Challenges

Dynamic Environment

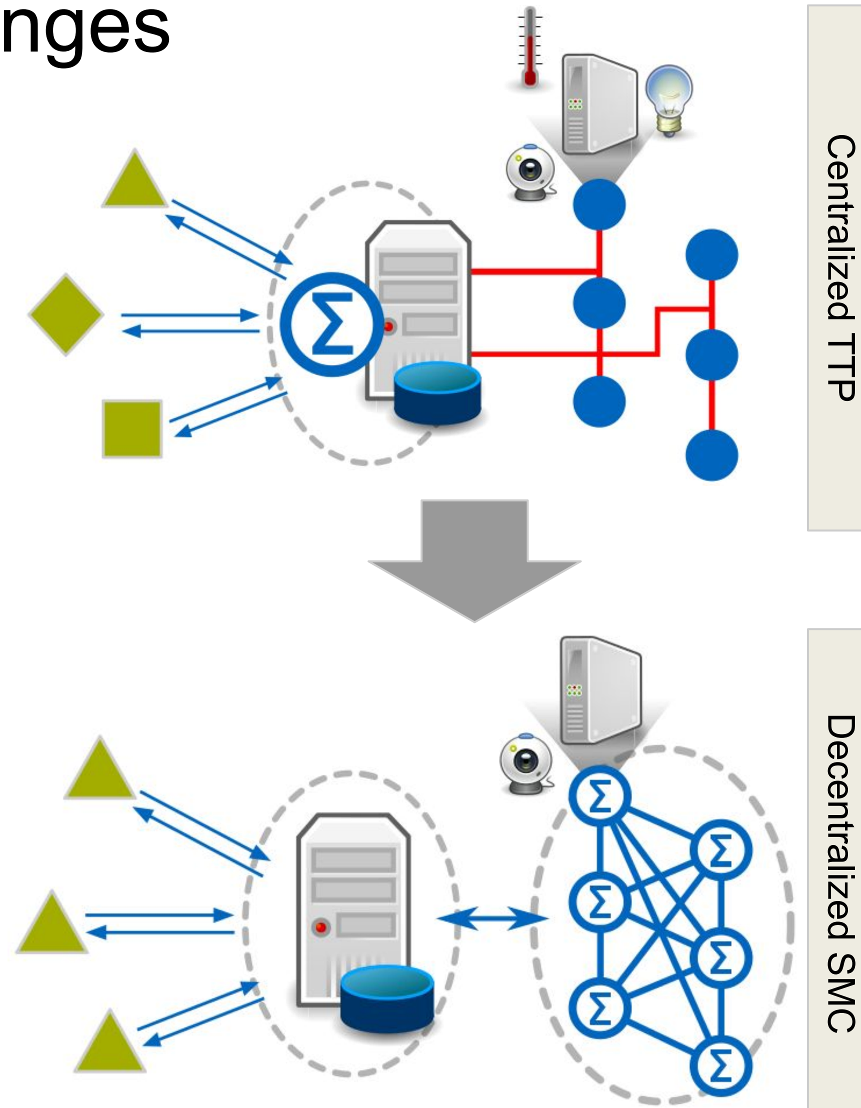
- Parties previously unknown
- Subsets of Parties
- Different input data
- Computations previously unknown

Orchestration of Computations

- Synchronized communication
- No error handling

Service character

- Access for data consumers
- Metadata about available information
- Only parties obtain result



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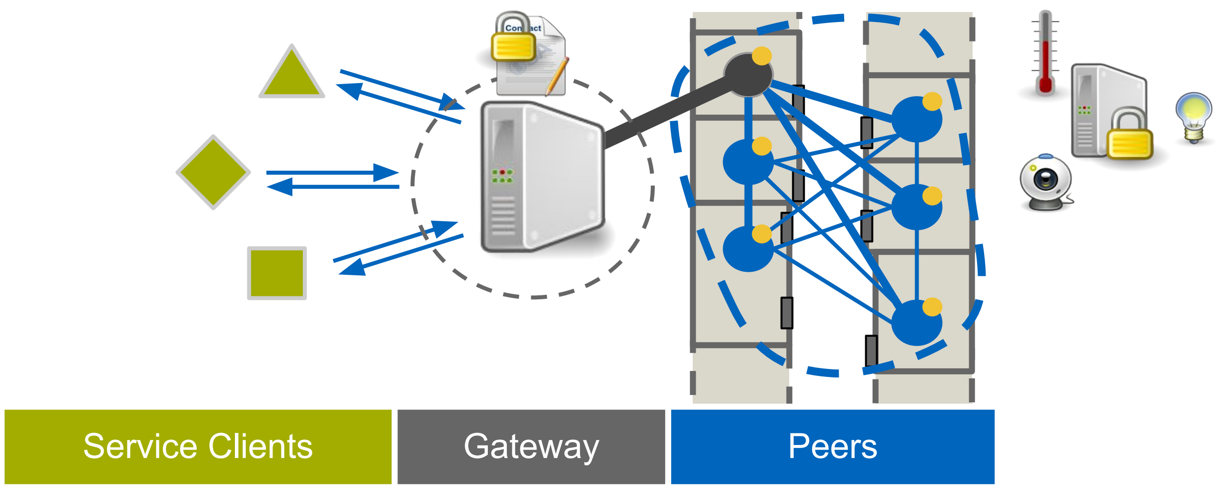
Architectural Overview: Hybrid Approach

Virtual Centrality

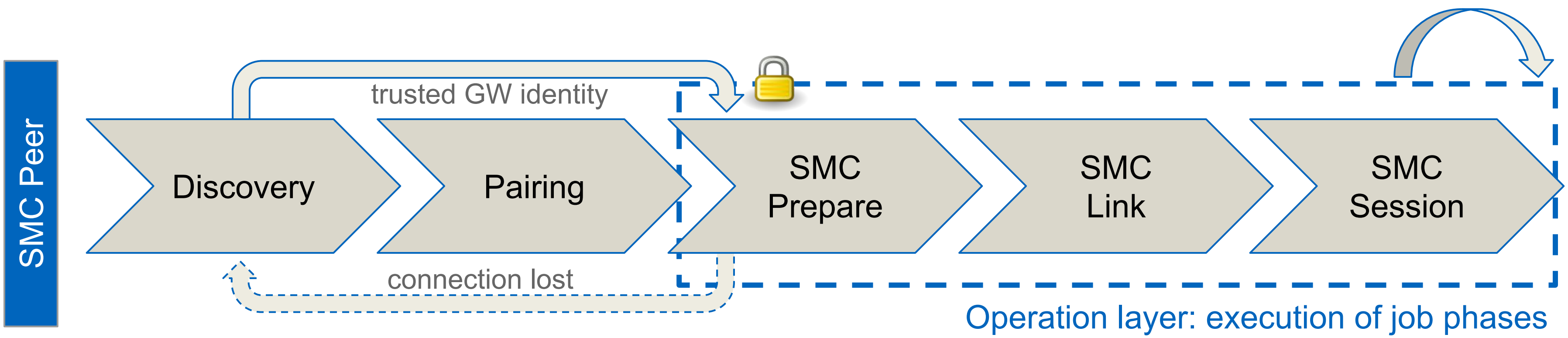
- Introduction of gateway (GW) for SMC network
- Single, generic endpoint for requests
- Hides complexity and fragility of SMC network

Decentralization

- Self-management
- Local storage of raw values
- Only reveal processed data via collaborative computations (SMC)

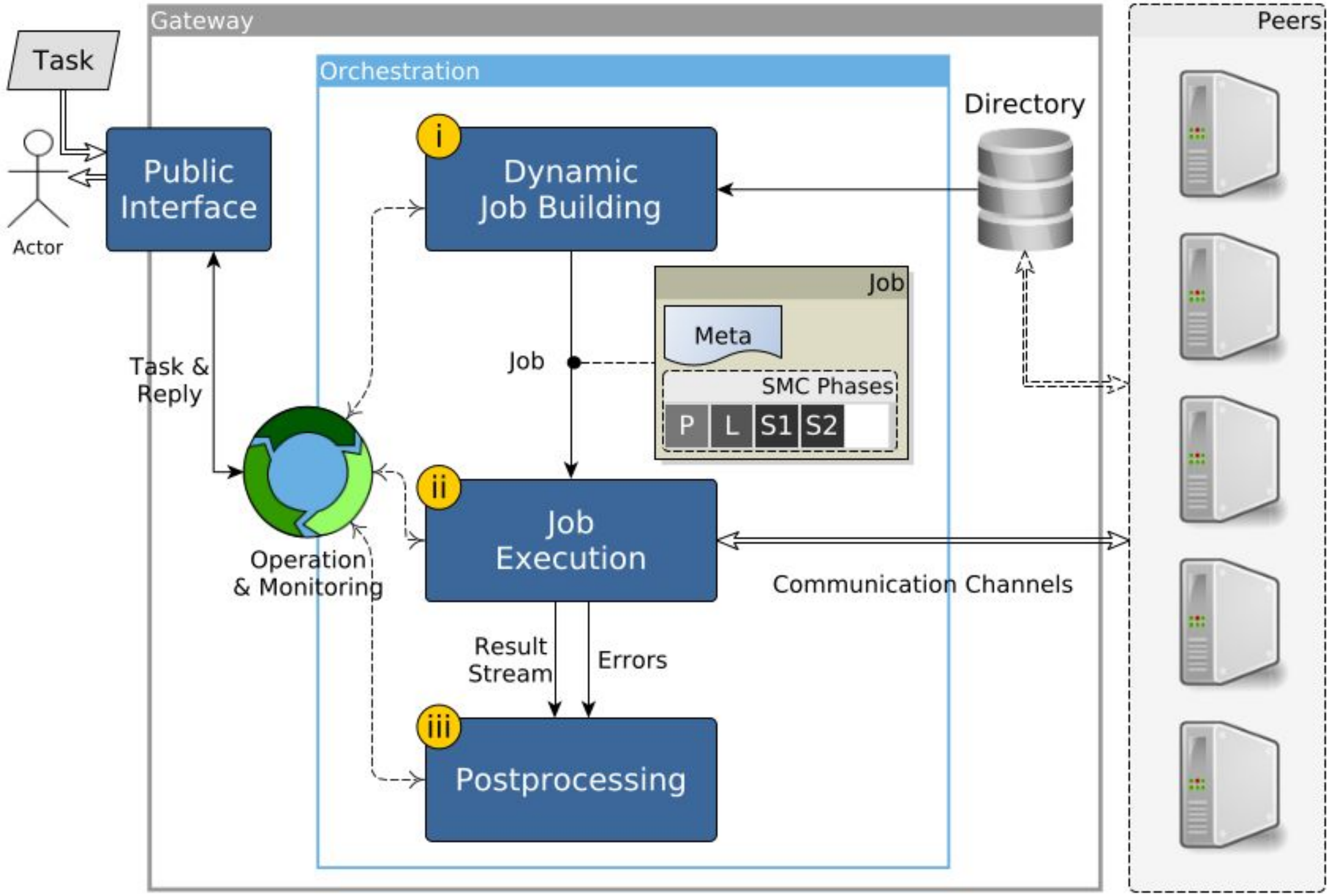


Peers | Self-Organization



- Discovery
  - Zeroconf
  - Find Gateway
- Pairing
  - Match capabilities
  - X.509 certs exchange
  - (Out-of-bound verification)
- SMC Prepare
  - Request verification
  - Prepare request for computation
- SMC Link
  - Connect peers with each other
  - Check for problems
- SMC Session
  - Synchronized trigger of session(s)
  - Stream results to requesting client

Gateway


Gateway
Task
Actor
Public Interface
Task & Reply
Orchestration
i
Dynamic Job Building
Directory
Job
Meta
SMC Phases
P
L
S1
S2
Job
Operation & Monitoring
ii
Job Execution
Communication Channels
Result Stream
Errors
iii
Postprocessing
Peers

Realized Features

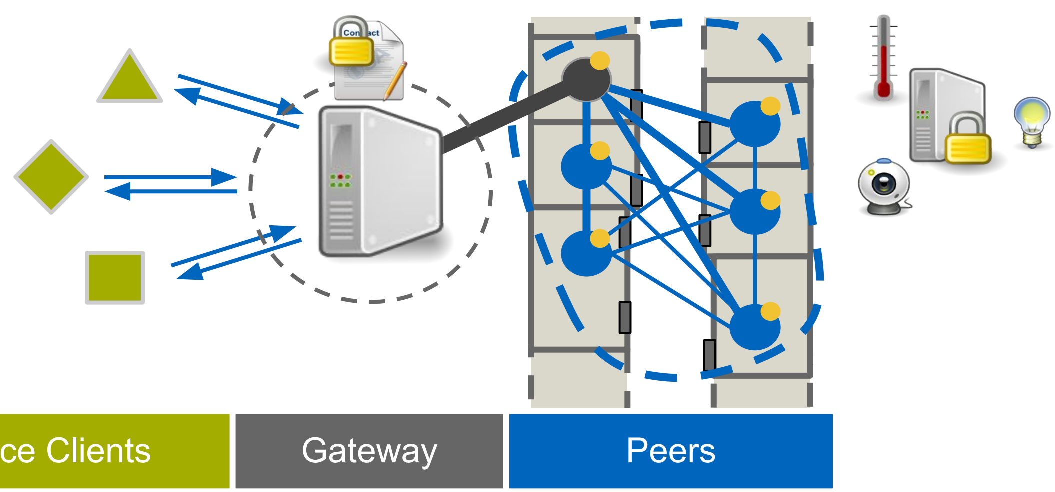
Applicability

- Adaptiveness in dynamic environments
- Automatic session configuration
- Automated and continuous execution of SMC
- Robustness of computations

Privacy

- Confidentiality
- Unlinkability of data
- Data minimization
- Transparency of data-processing
- Intervenability for peers

(Confidentiality, Unlinkability of data, Data minimization: SMC)



Conclusion

- Secure multiparty computation realizes/supports realization of privacy properties
- New challenges arise when applying SMC in dynamic contexts
- We propose a wrapper around SMC to solve to these problems
- Then, SMC can be used as a robust service for continuous and automated computations