Modelling Dynamic Trust Contracts for Industry 4.0 Systems

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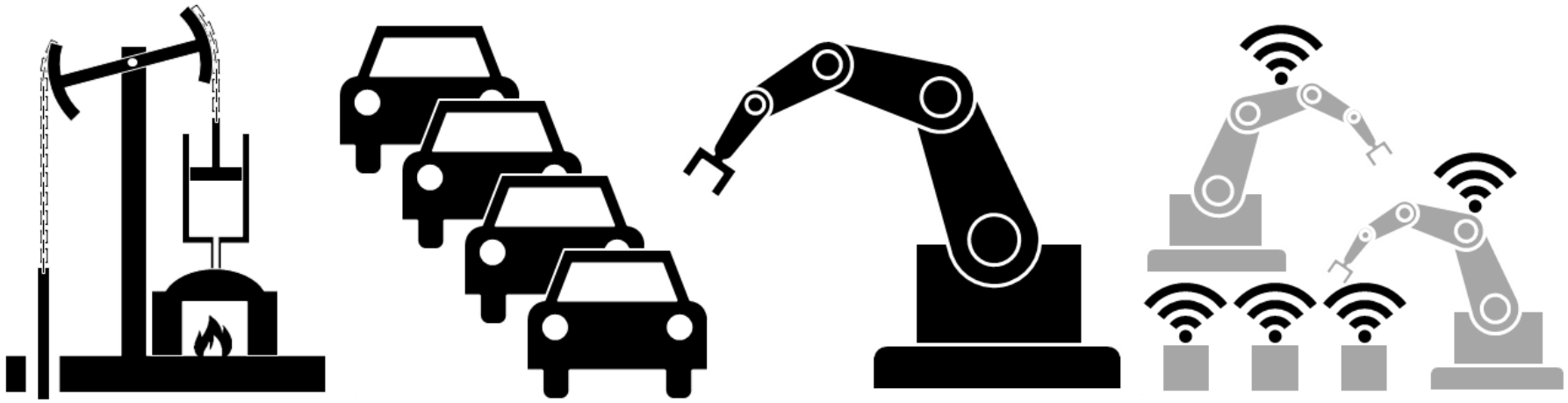
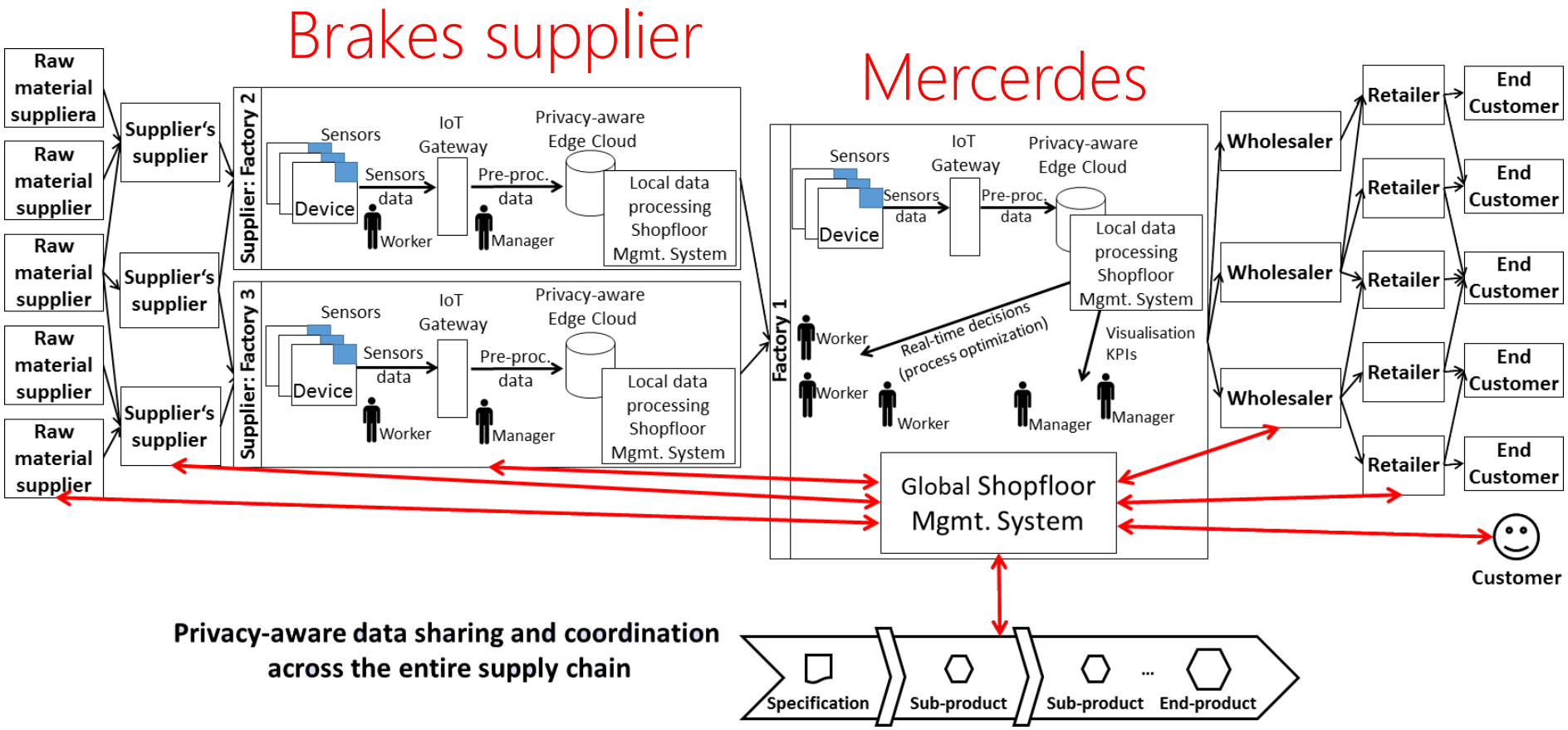
Industry 4.0



1st	2nd	3rd	4th
Mechanization, water power, steam power	Mass production, assembly line, electricity	Computer and automation	Cyber Physical Systems

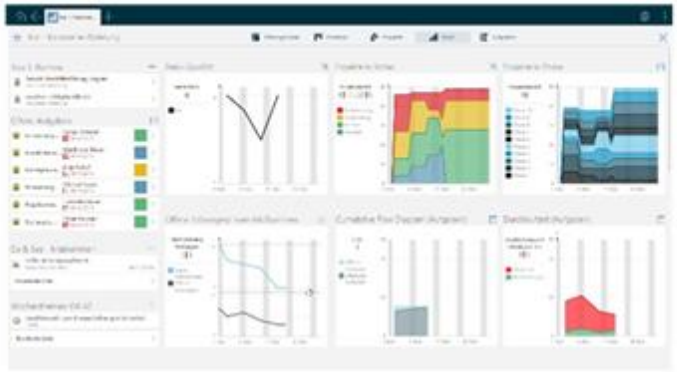
Data sharing across supply chains



- **Dynamic context**: analytics and predictions, legal framework, business process, roles, organisational structure, time, location and privacy.

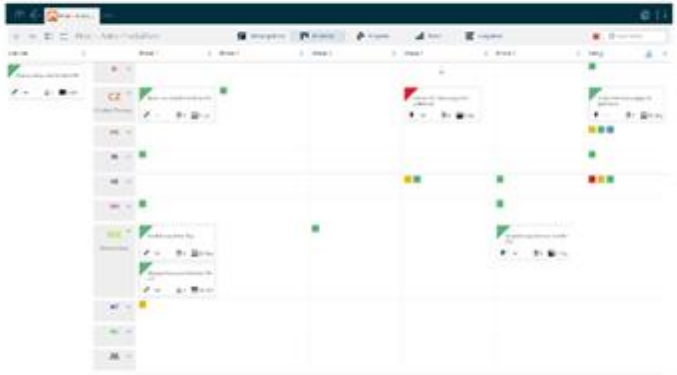
valueStreamer: Shopfloor mgmt. system

Team



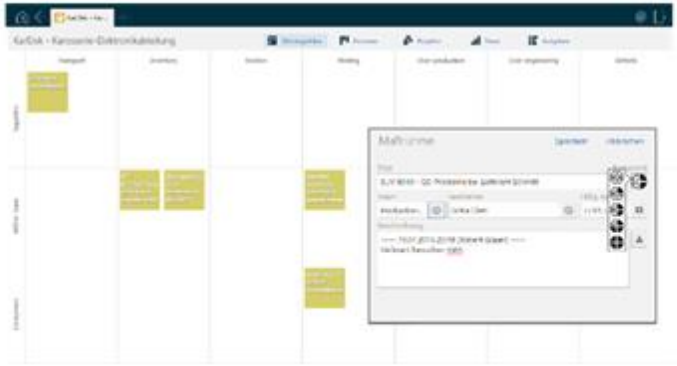
Projects

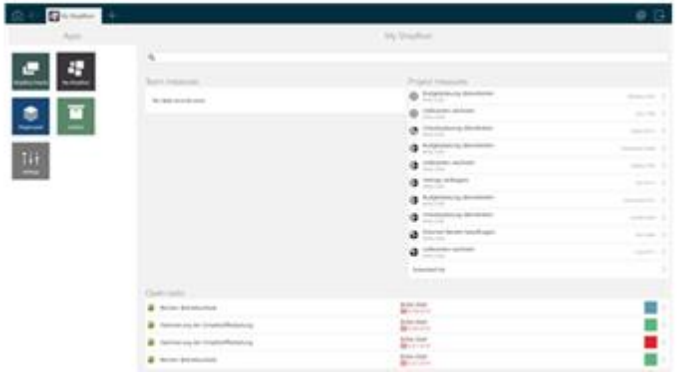
Process



Tasks

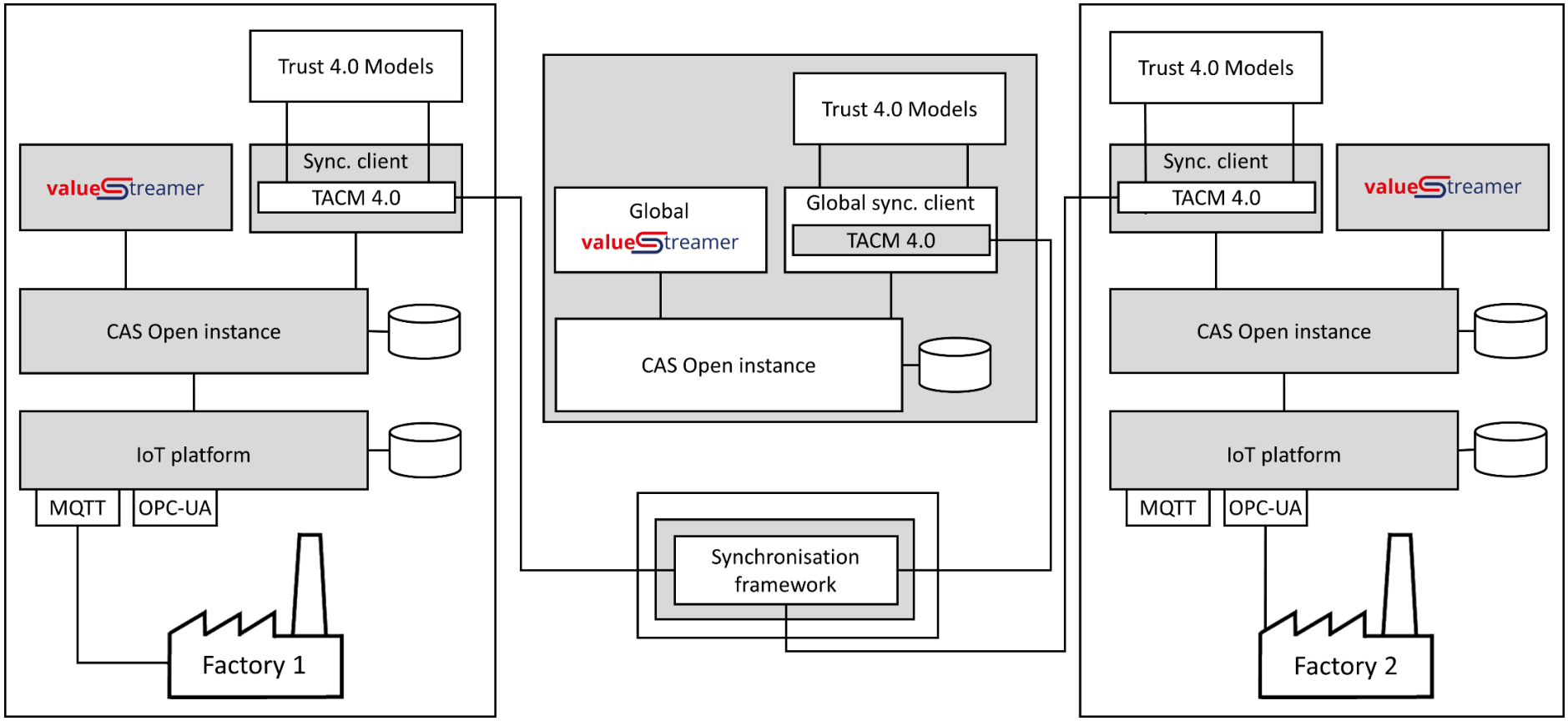
Actions





Shopfloor

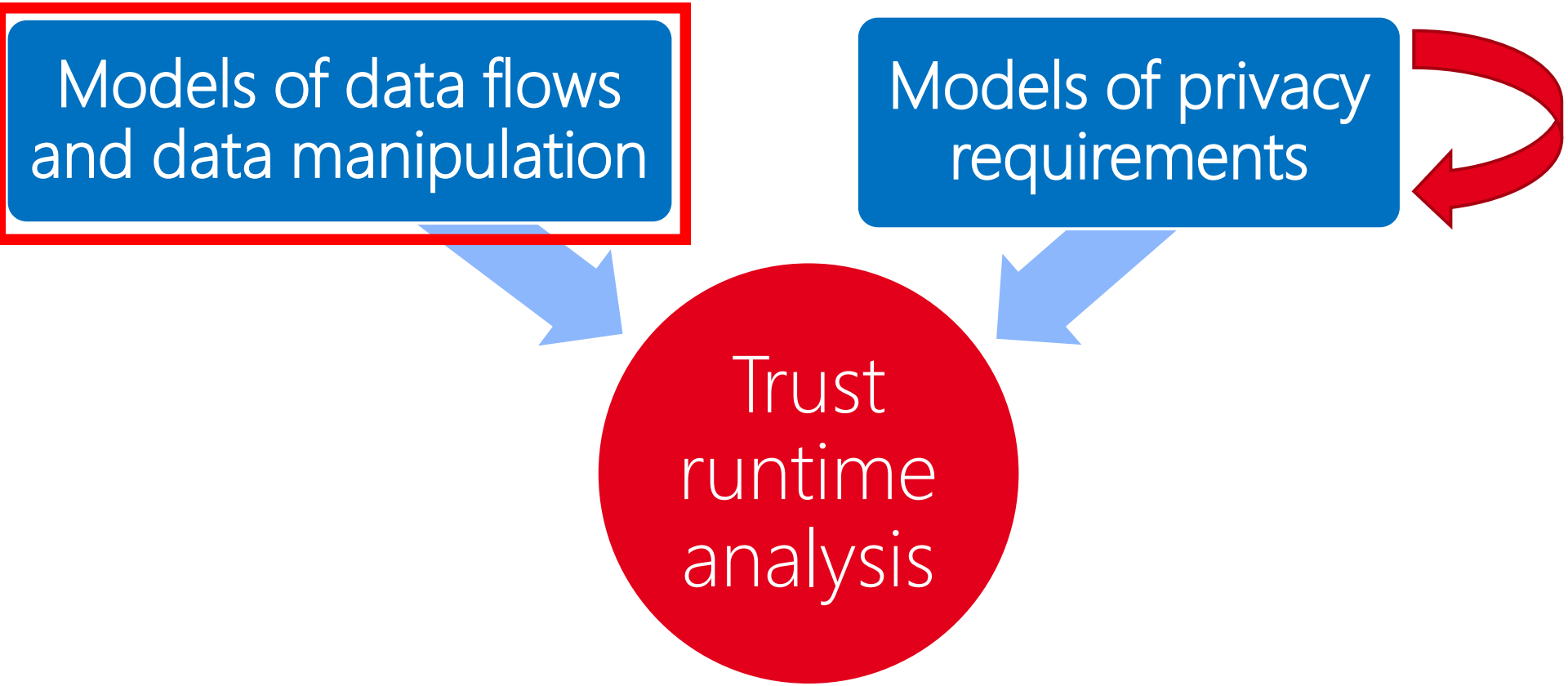
ValueStreamer across the entire supply chain



State of the art

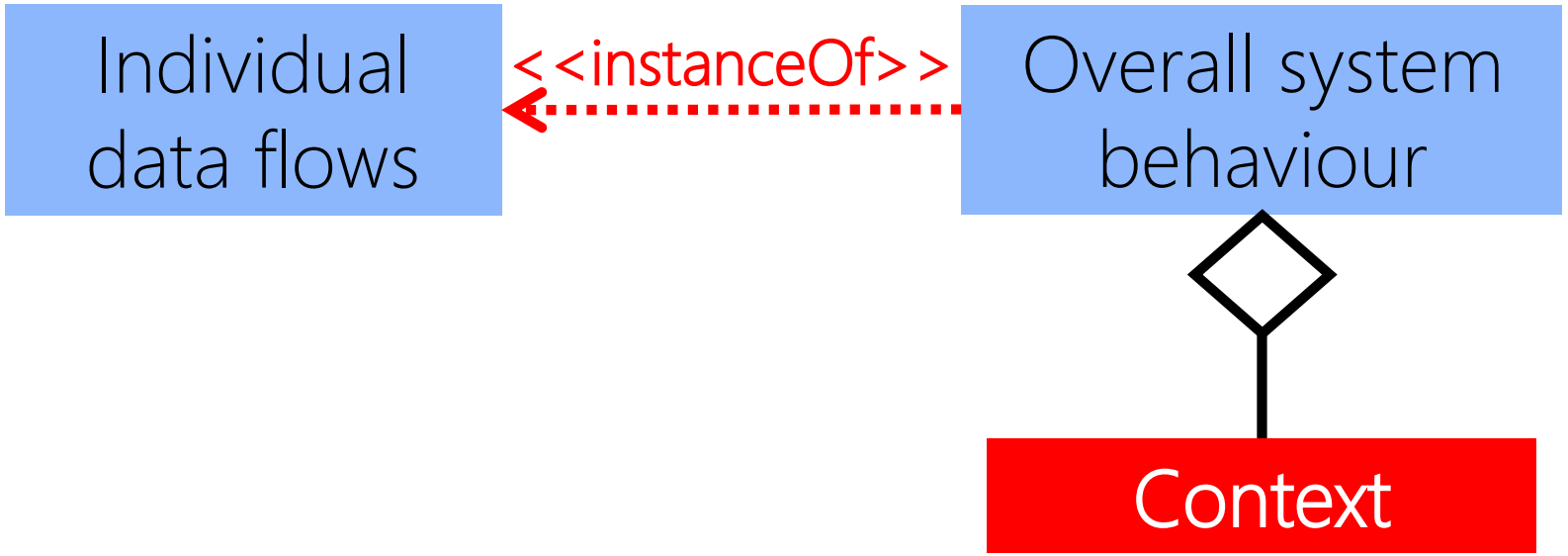
- **12 papers** around confidentiality in software design and software operation:
  - confidentiality analyses
  - access control
  - security enforcement
  - data sensitivity
- **Access rights mgmt**, **heterogeneous** and **dynamic** environments, **design time**, enforcement platform, **privacy levels** data sharing with operators

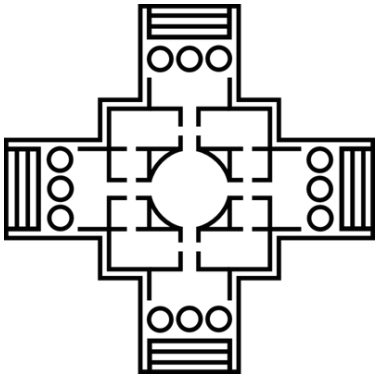
Trust 4.0 approach



Models of data flows & data manipulation (1/2)

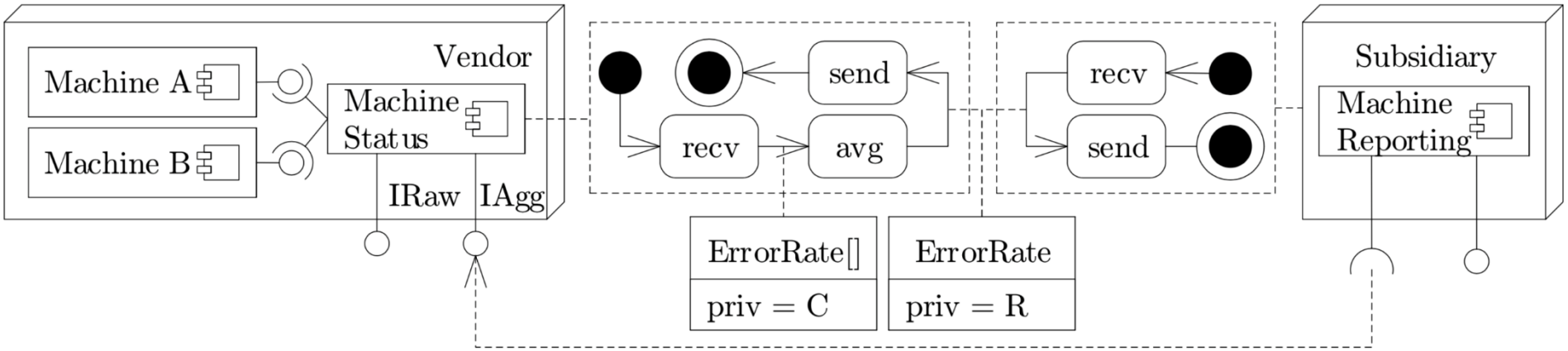
- System and processes



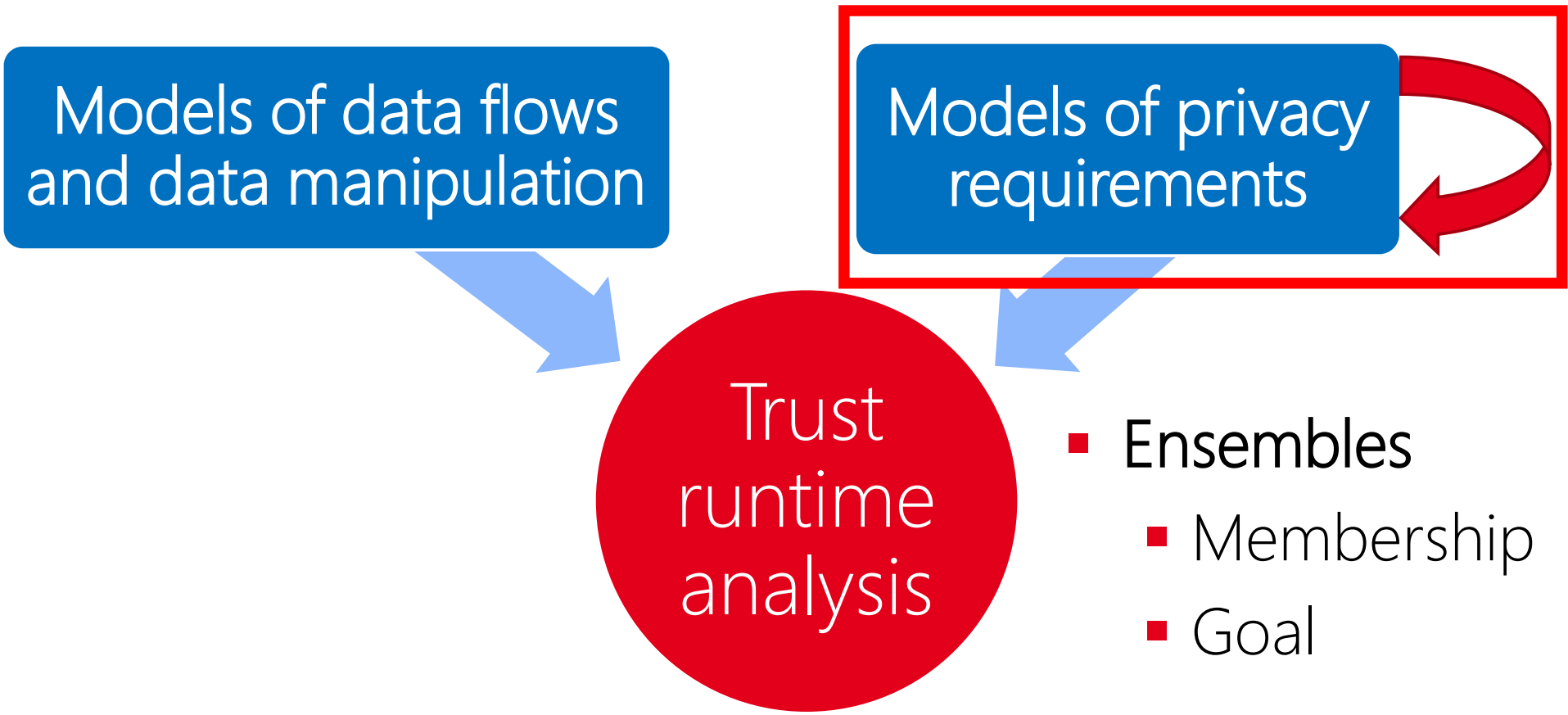


- Palladio Component Model (PCM)

Models of data flows & data manipulation (2/2)



Trust 4.0 approach



- **Ensembles**
  - Membership
  - Goal

Models of privacy requirements (1/2)


```
class SharingWithServiceman(val machine: Machine) extends Ensemble {
  val servicemen = role(entities.select[Person].filter(_.hasRole{ case Serviceman(machine) =>
          true } ))
  val accomp = role(entities.select[Person].filter(_.hasRole{ case
          Technician(machine.department) => true } ))
  where( servicemen.all(svc => accomp.some(acc => svc.location == acc.location)) )
  allow(servicemen, machine, "errorRates")
}
```

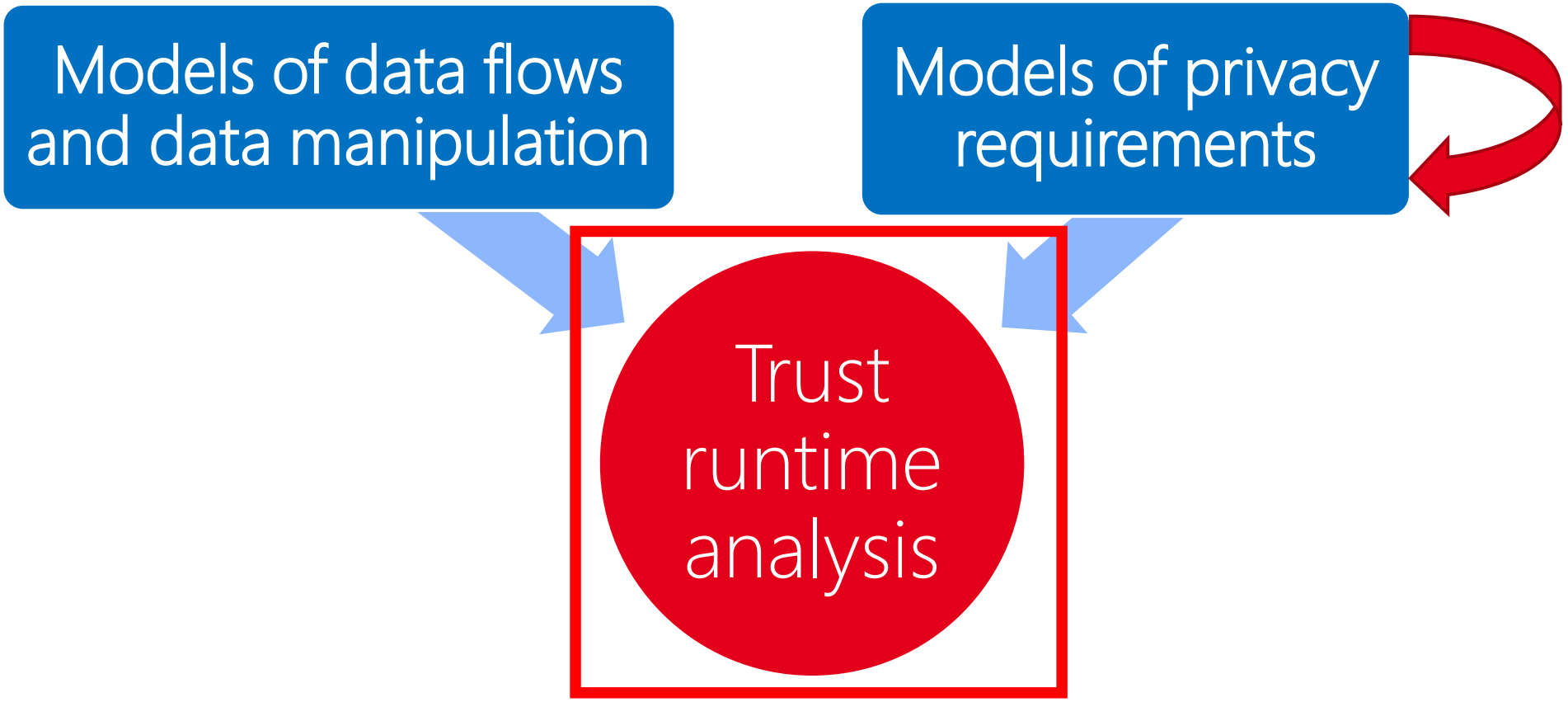
A **subcontractor's technician** fixing a machine may see its detailed **error rates** log but only together **with a technician** of the department responsible for the machine.

Models of privacy requirements (2/2)


```
class SharingWithSubsidiary(val company: Company) extends Ensemble {
  val machines = role(entities.select[Machine].filter(_.company == company))
  val persons = role(entities.select[Person].filter(
    _.hasRole{ case HeadOfCompany(subsidiary) => subsidiary.parentCompany == company } )
  allow(persons, machines, "sum(errorRates)", PrivacyLevel.RESTRICTED)
}
```

The **brake supplier share its error rates** with the head of a subsidiary company, e.g. for quality improvement, but only after proper **anonymization** to not reveal details of the manufacturing process.

Trust 4.0 approach



Trust analysis (1/3)

1. PCM runtime analysis determines system characteristics such as **privacy levels of sent data**
2. Trait-based Coalition Formation Framework (TCOOF) evaluates ensembles and derives **decisions** by means of access permissions

Trust analysis (2/3)

1. PCM

- Characteristic: privacy levels of data
- Location: transmission link

- Analysis: data processors of all possible paths of data to location and effects of processing

- Result: average error rates

Trust analysis (3/3)

2. Decision Making based on TCOOF

1. Which contracts are relevant?
   - Relatively new in dynamic systems
   - Ensemble -> constraint solving problem (Choco)
   - Constraint (membership, context)
2. Allow/deny data sharing

Conclusion

- **Dynamic systems** with architectural modelling
- **Security and privacy not static**
  - not only roles and hierarchy but roles + dynamic context
  - coordination of multiple parties

- Contributions
  - **data flows** described in **system architecture**
  - **dynamic data sharing** based on context
  - **runtime analysis platform** for data exchange

Next steps

- **Refine** requirements. Technical report. Two pilots
- **Simplify** domain specific language
- Offer security and privacy guarantees at **design time** in dynamic systems
- **Scalability** and **decentralise** security and privacy
- **Validation** in two industrial pilot demonstrators

Thanks!

- Contributions
  1. **data flows** described in **system architecture**
  2. **dynamic data sharing** based on context
  3. **runtime analysis platform** for data exchange

Reference architecture