Monitoring and Explanation of Contract Execution:

A Case Study in the Aerospace Domain

Felipe Meneguzzi Sanjay Modgil
Nir Oren **Simon Miles** *King's College London*
Michael Luck

Nora Faci *University of Lyon*

Camden Holt Gary Vickers *Lost Wax*

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Outline

- Motivation and Context
- Aerospace Aftermarket
- Monitoring Contract Fulfilment
- Explanations of Violations
- Simulation Scenarios
- Conclusions and Related Work

INTRODUCTION

Electronic Contracts in MAS

- Systems of self-interested agents:
  - Inherently unreliable
  - Require societal control
- Norms used to regulate agent behaviour:
  - Encourage compliance with societal goals
  - Expressed using deontic concepts
- Norms incorporated into an agreed formal document → *Contract*

Electronic Contracts in Use

- Many domains match the pattern of self-interested but co-operating agents
- For example, businesses use each others' services without assuming that everything in their own interest is in the interest of others
- People draw up contracts to formalise business relationships or transactions
- Electronic contracts allow automation of the processes surrounding contracts

The CONTRACT Project

- Aiming at an electronic contracting framework:
  - Facilitates design, verification, enactment, and management of contracts
  - Includes critical aspects of a contract life cycle

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Use Cases

- The project draws requirements and inspiration from a set of use cases provided by companies
  - Insurance brokering
  - Testing services
  - Software provision
  - **Aerospace aftermarket**

AEROSPACE AFTERMARKET

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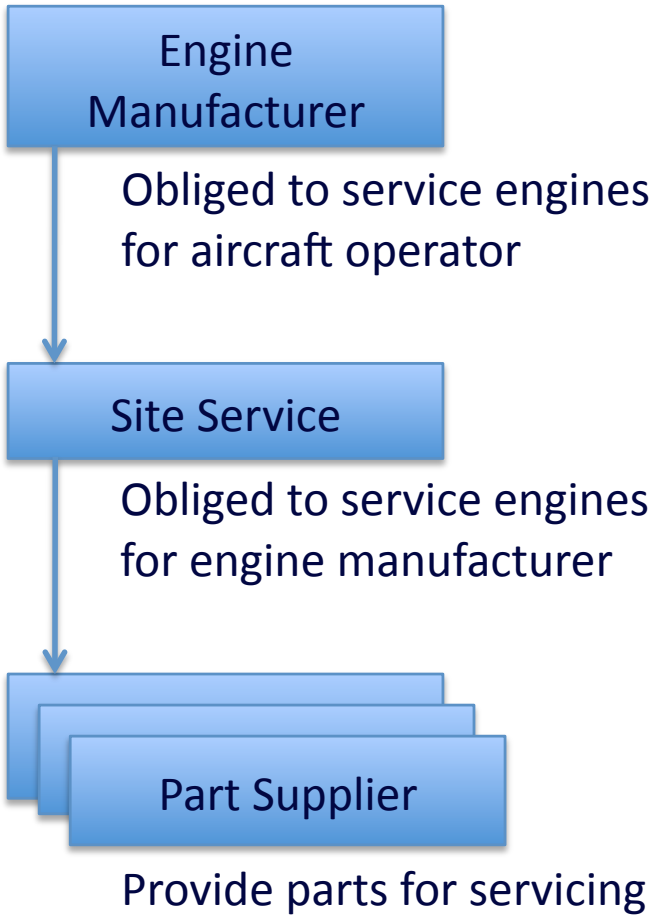
Aerospace Aftermarket

- Aircraft operators purchase engines from engine manufacturers
- The engines need to be maintained over their lifetimes: ***aftercare***
- This service is provided by the manufacturer but delegated down to particular ***sites*** where the planes can land and engines be serviced

Aftercare Contracts

- Consider contracts between engine manufacturers and service sites
- Contract obliges service site to service each engine within a given period
- Servicing requires ordering, fitting new engine parts
- There can be contractual restrictions on which part suppliers are acceptable



MONITORING CONTRACT FULFILMENT

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Representing Clauses

- A contractual clause is expressed by five elements

Element	Description
Type	Obligation or permission
Activation Condition	Conditions under which this clause takes force
Normative Condition	Conditions under which the obligation is being met or permission is taken advantage of
Expiration Condition	Conditions under which this clause ceases to take force
Target	The agent obliged or permitted by this clause

Case Study Clauses

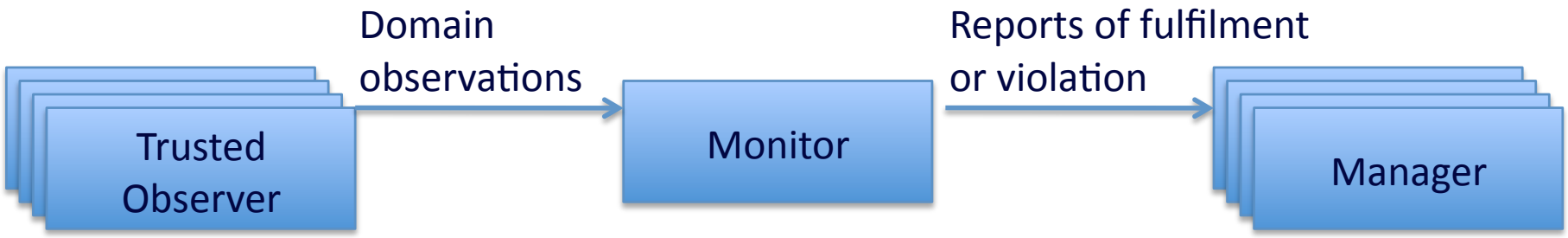
- The clause below obliges the service site to service the engine in 7 days

Element	Description
Type	Obligation
Activation Condition	Engine E requires repair at time T
Normative Condition	Engine E is repaired or T + 7 days has not yet been reached
Expiration Condition	Engine E is repaired or T + 7 days has passed
Target	Service site

- Additionally, we have clauses to permit 2 part suppliers to be used and prohibit use of another

Monitoring

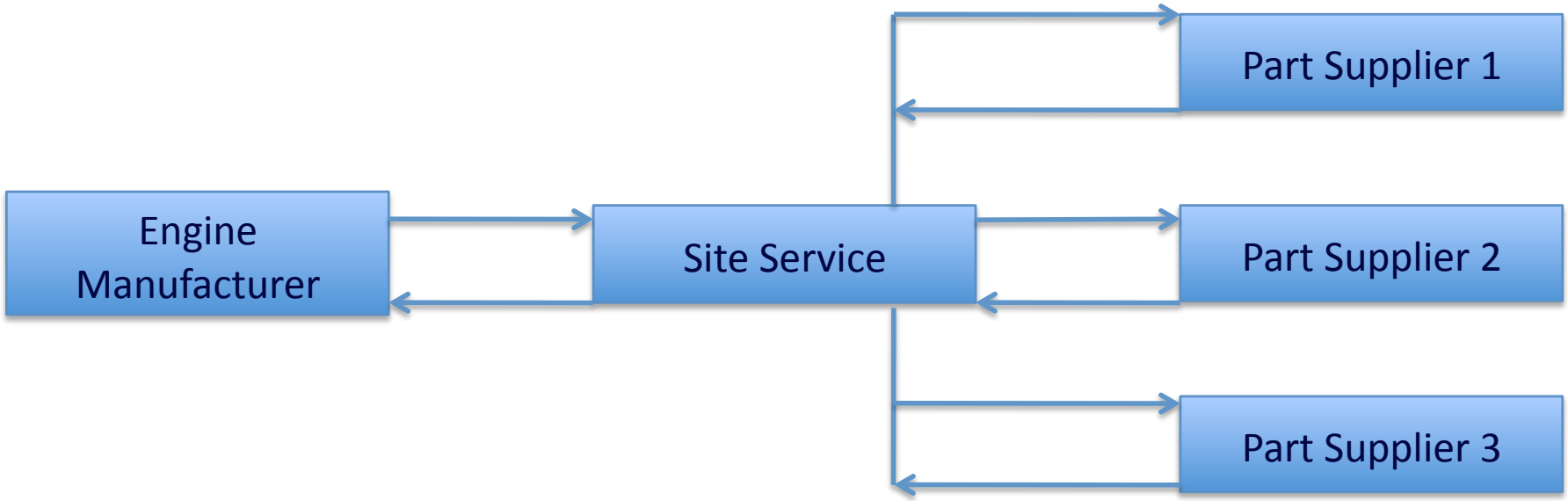
- An important factor for aftercare contracts is ensuring that the contract is adhered to, and violations are handled appropriately
- A key part of that is **monitoring** for compliance with contract clauses



A Framework for Monitoring Agent-Based Normative Systems, Modgil et al., AAMAS 2009

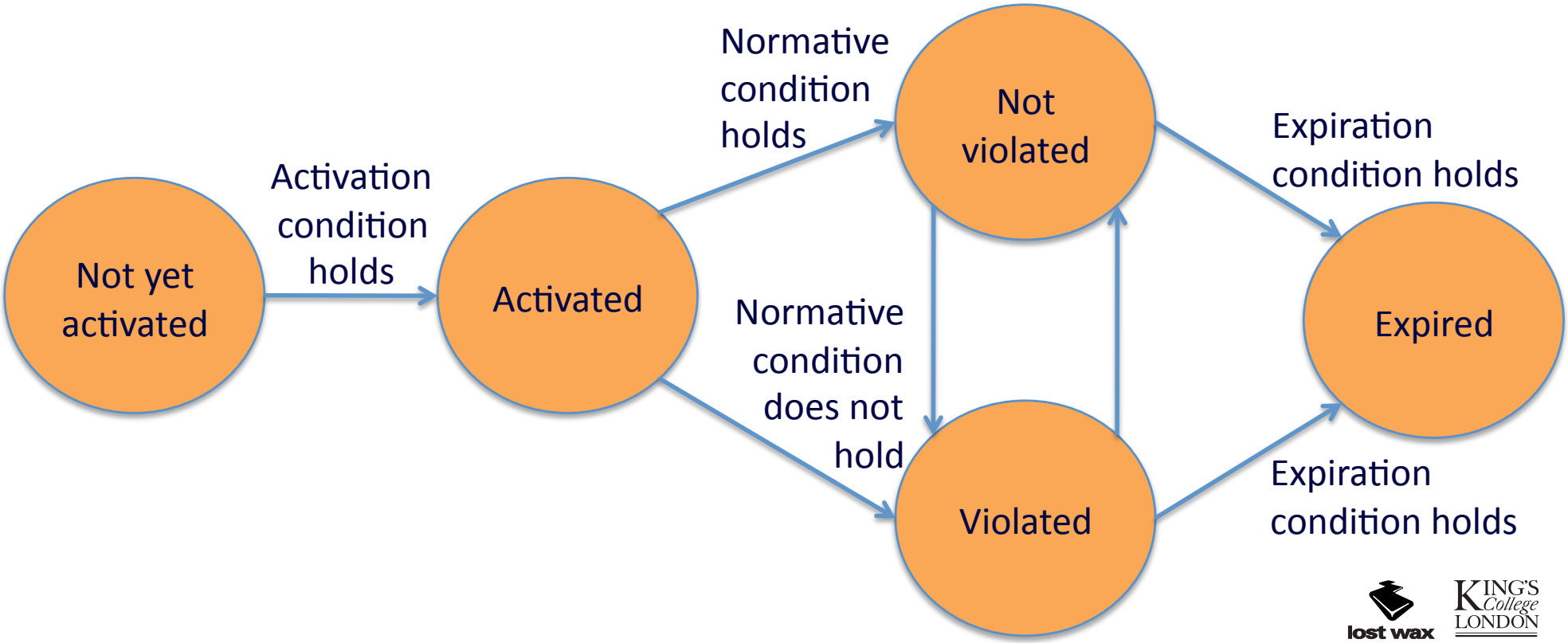
Domain Observations

- Agents interact through message exchanges
- These can be observed by the communicating agents themselves or intermediaries



Monitoring Status Representation

- Each clause monitored is represented as a graph
- As activating, normative or expiration conditions are observed, the graph is traversed to a new state



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EXPLANATIONS OF VIOLATIONS

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Explaining Contract Violations

- The observations which cause a monitor to transition from one state to another can be used as an explanation of a violation
- However, this just provides the **immediate** context of a violation
- For example, if an engine was not serviced within the time period, the observations would tell you which engine and when it required service

Improving Explanations

- By its nature, monitoring involves data relevant to contract clauses to be acquired
- We can improve explanations by making explicit where one clause is **linked** to another
- For example, an engine part is ordered from a supplier because an engine requires servicing
- We can also improve by adding and linking **virtual clauses** not in the contract but similarly monitored for explanation purposes

SIMULATION SCENARIOS

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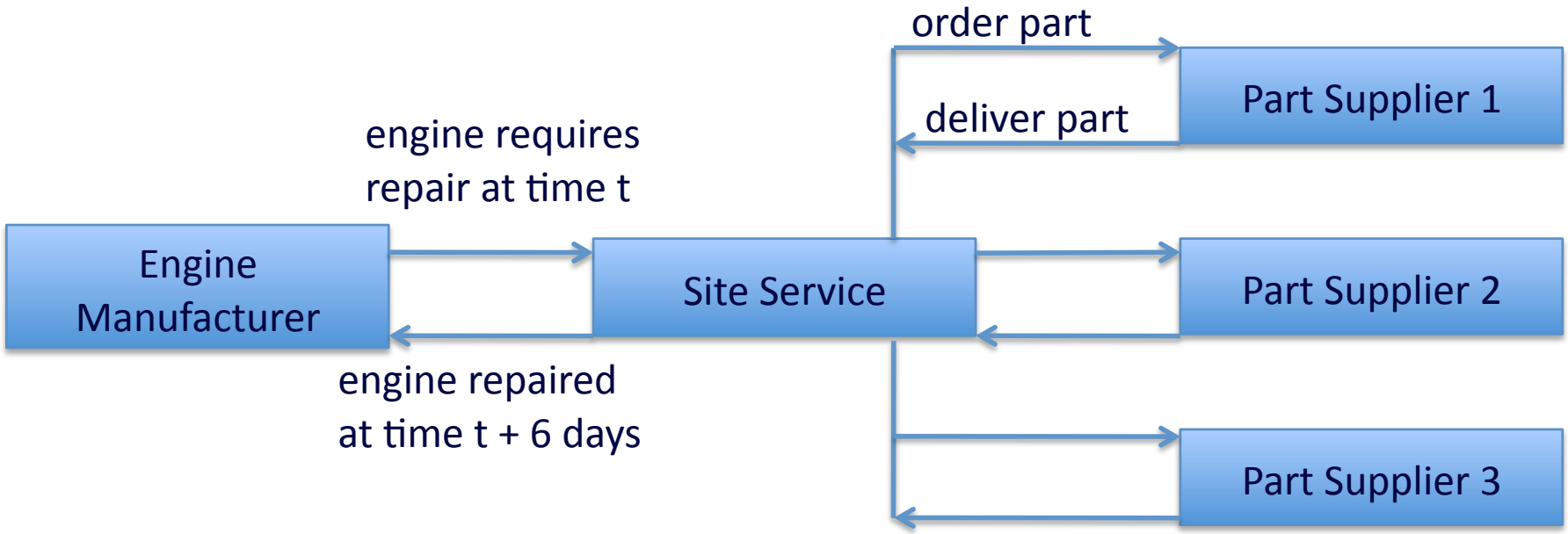
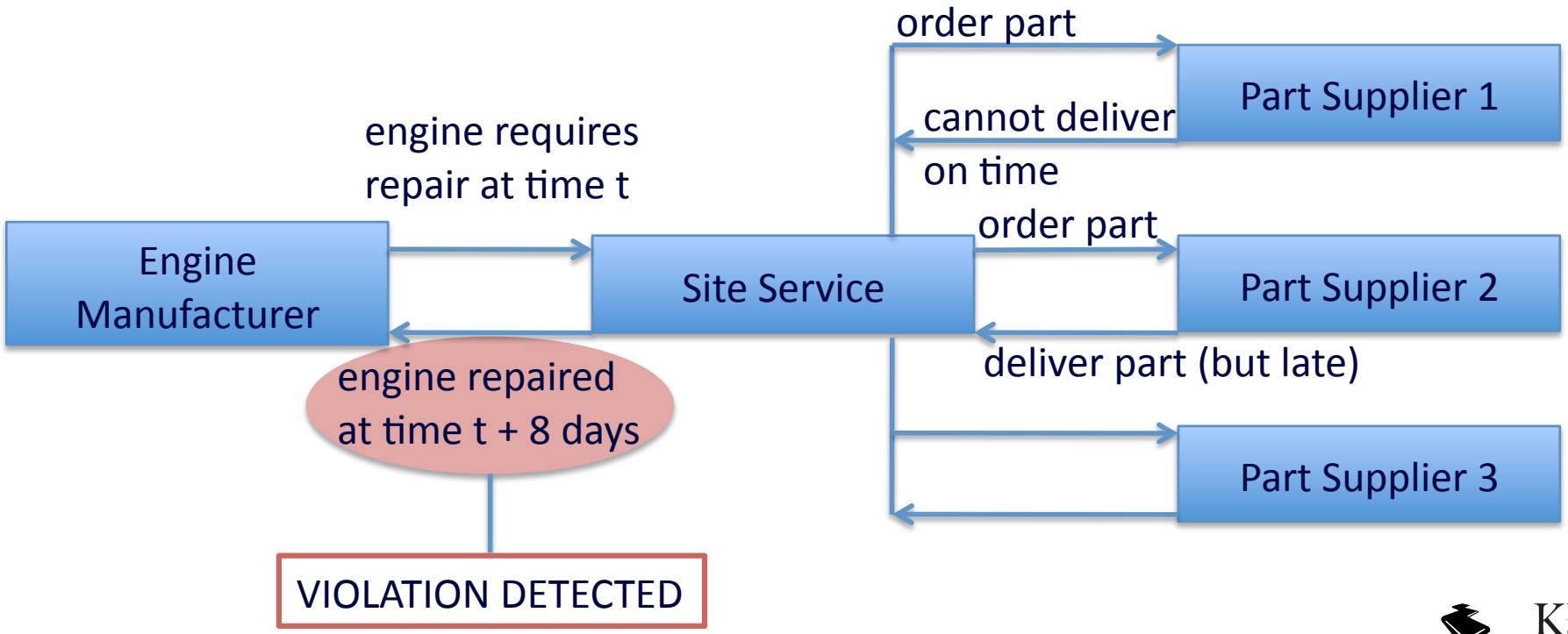
Scenario 1

- We tested three scenarios
- In the first, repair is successfully completed on time



Scenario 2

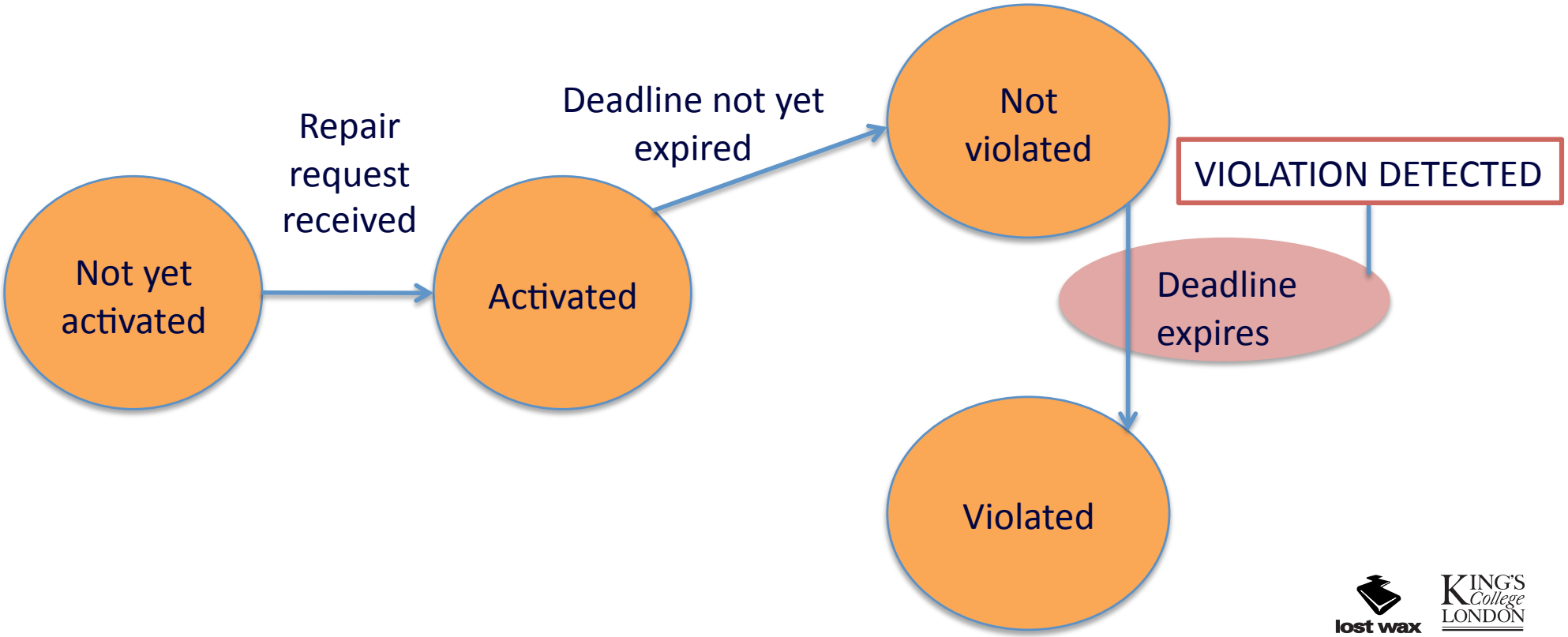
- In Scenario 2, the part supplier 1 cannot deliver parts on time, part supplier 2 delivers but late, delaying the repair



Explanation from Monitoring

Obligation to repair engine within 7 days

(we exclude expiration states for brevity)



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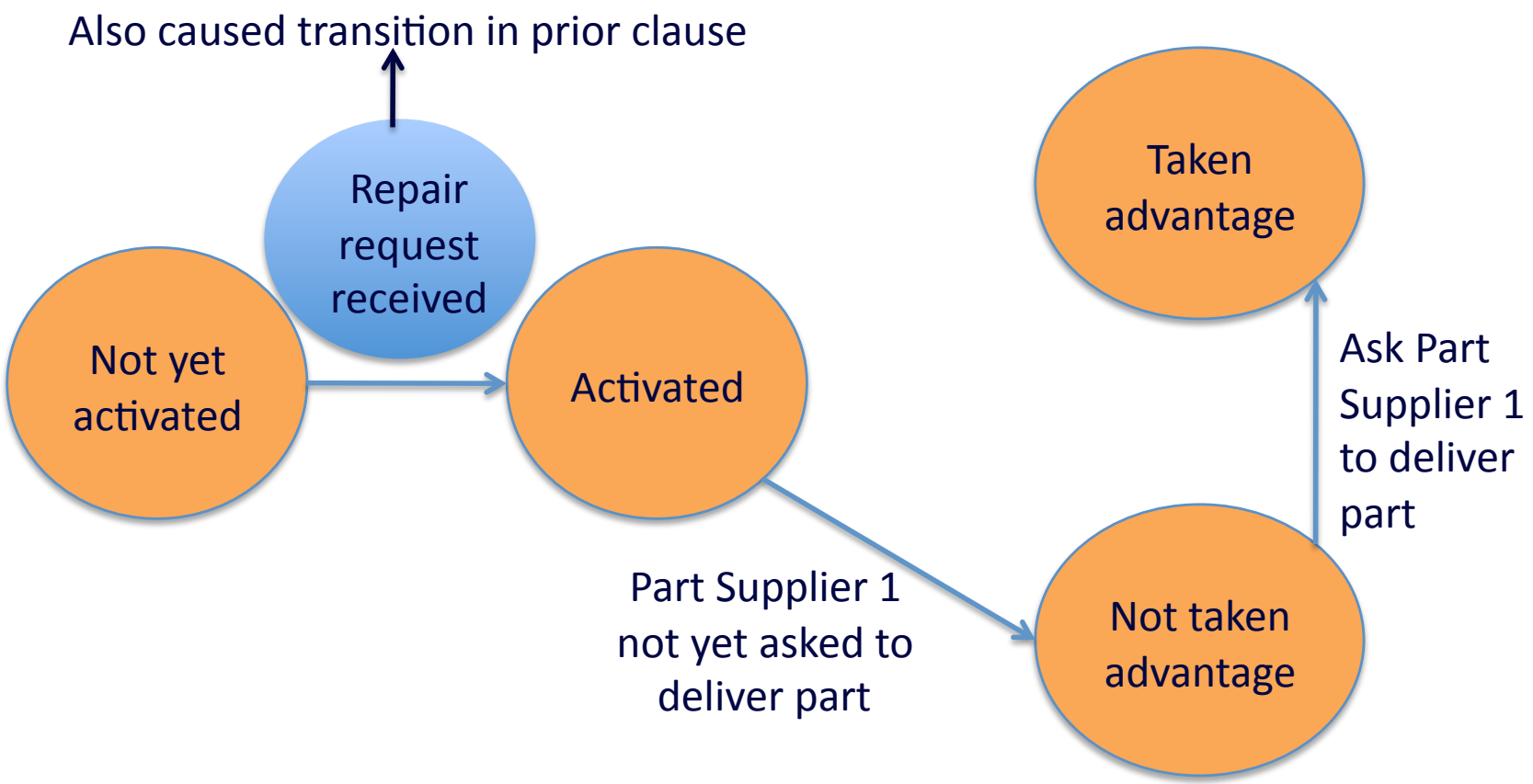
Explanation from Monitoring

Monitoring of permission to use Part Supplier 1



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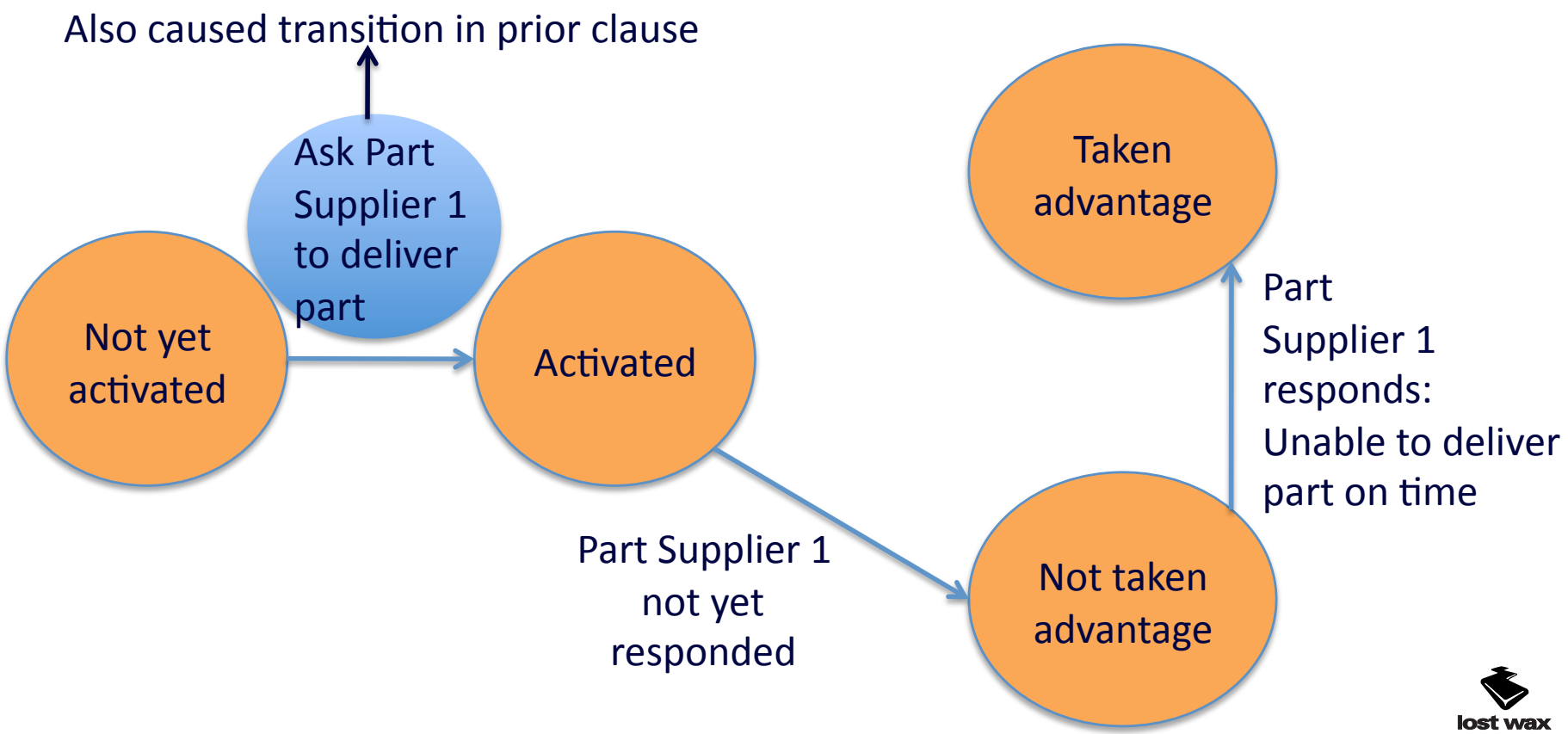
Explanation from Monitoring

Virtual clause to monitor Supplier 1's response



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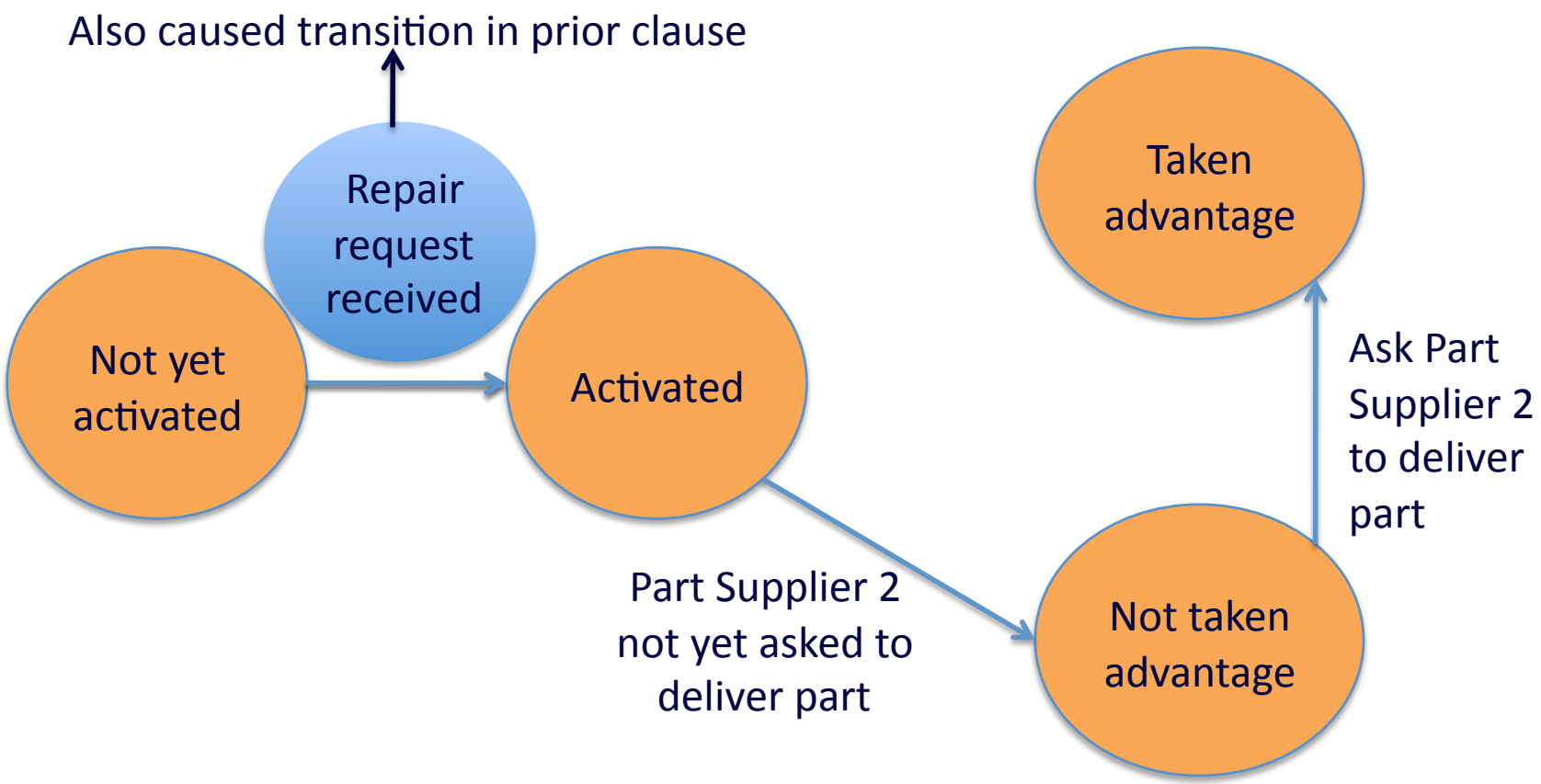
Explanation from Monitoring

Monitoring of permission to use Part Supplier 2



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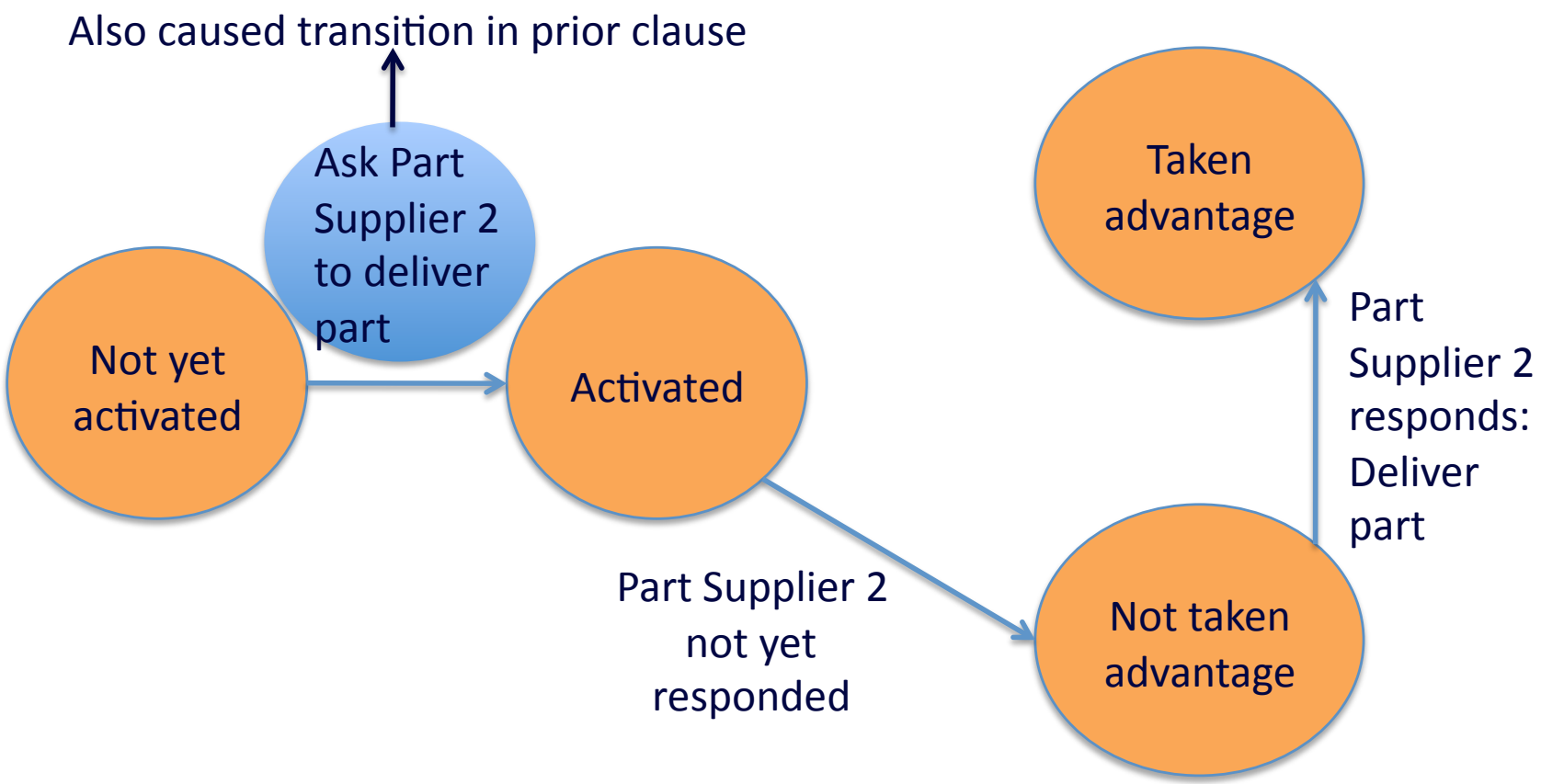
Explanation from Monitoring

Virtual clause to monitor Supplier 2's response



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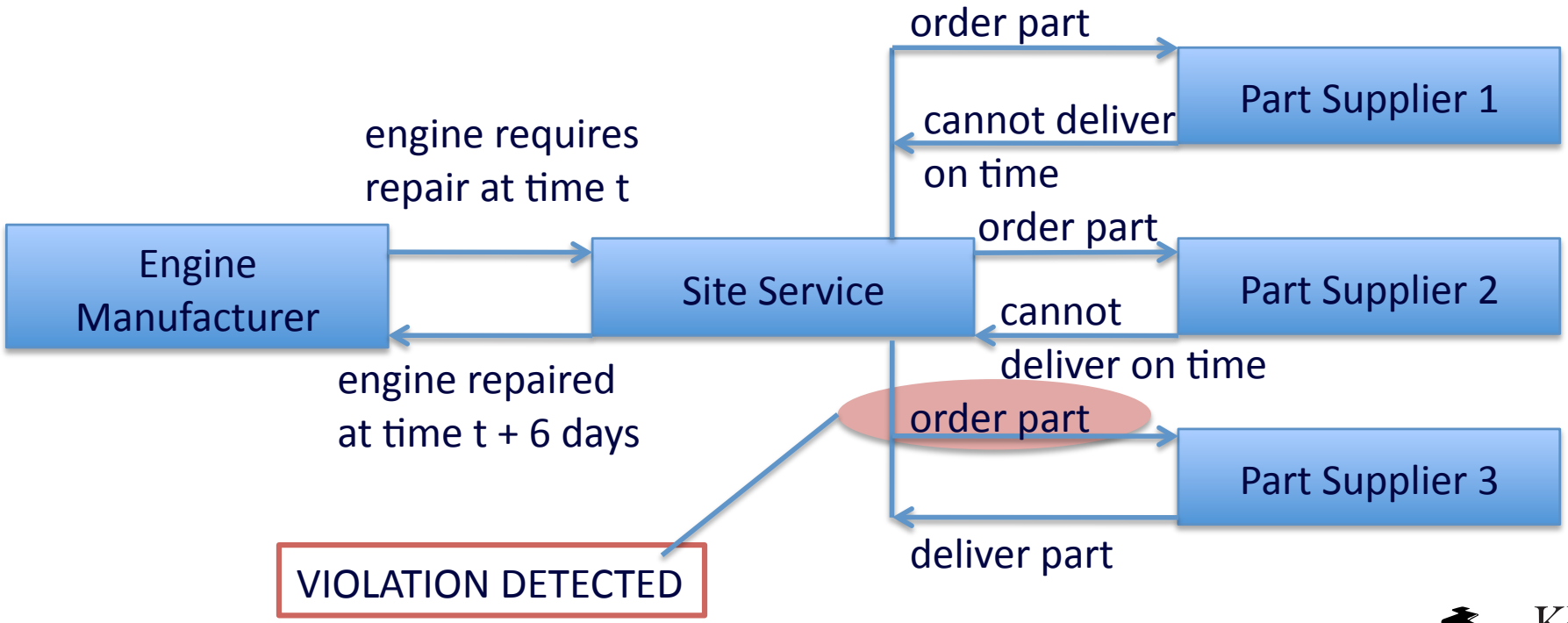
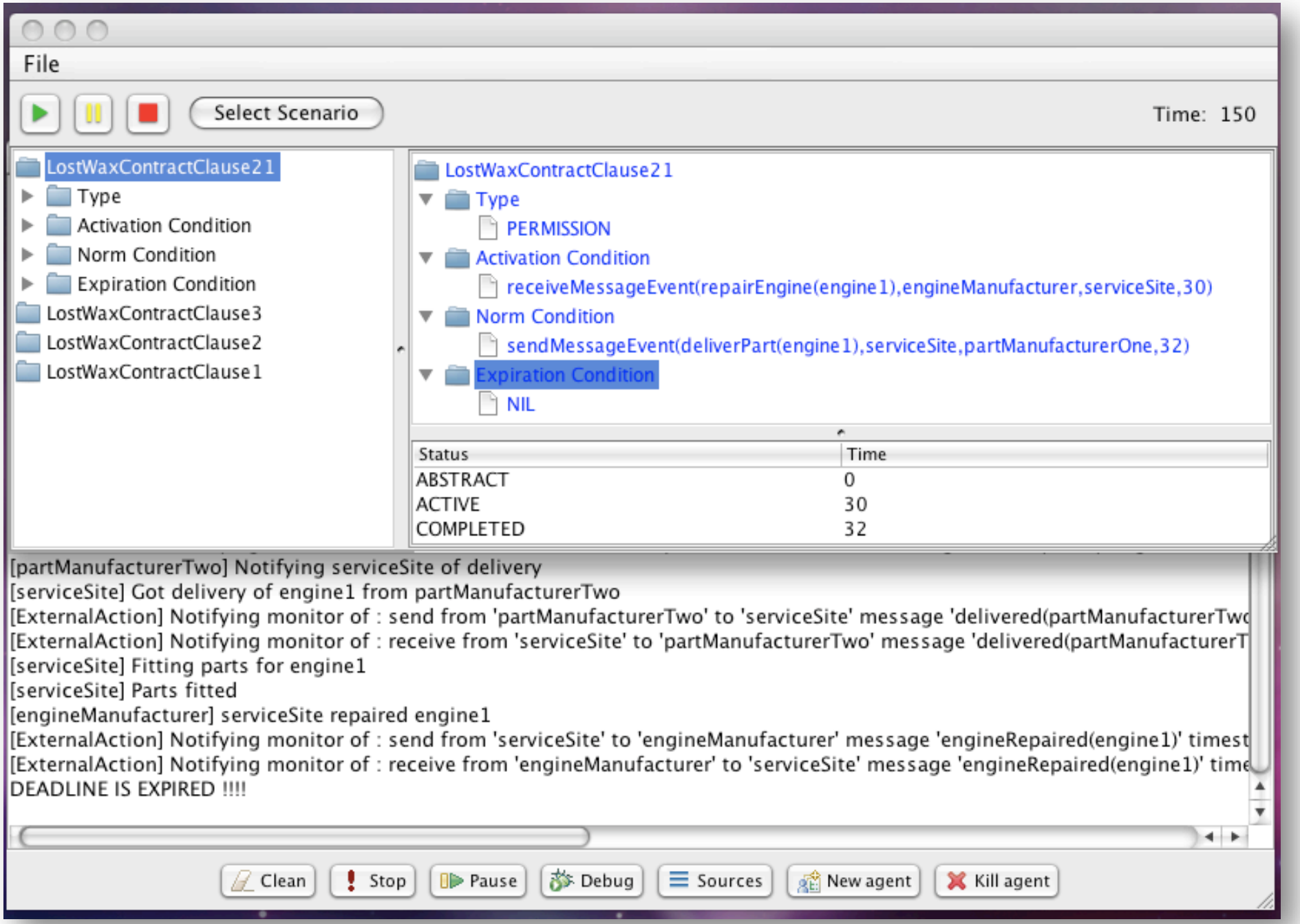
Scenario 3

- In Scenario 3, part suppliers 1 and 2 cannot deliver parts, part supplier 3 is used even though prohibited by the contract





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CONCLUSIONS AND RELATED WORK

Conclusions and Future Work

- Monitoring of electronic contracts adds value by allowing the diagnosis of contract violations
- Our work allows explanations to be generated for violations, enabling such diagnosis
- Future work:
  - Refine the detection and explanation algorithms
  - Methodology to develop virtual clauses for improved explanation