31st Annual INCOSE international symposium
virtual event
July 17 - 22, 2021

Applying Systems Engineering for architecting a Smart Parking System

Agenda

- Introduction
- Understanding the Context
- Developing alternate architectures
- Specifying chosen alternative and Validation
- Conclusion

Smart Cities and Smart Parking

Smart Cities:

- efforts to enhance experience of city dwellers and stakeholders
- by providing innovative facilities/amenities/governance
- using information and technology

Average driver in New York spends 107 hours/year searching for parking

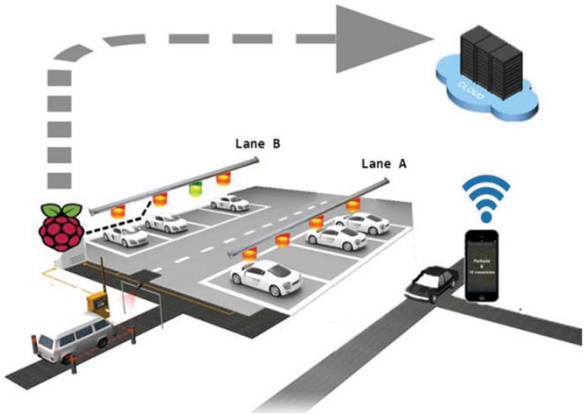
INRIX Study 2017

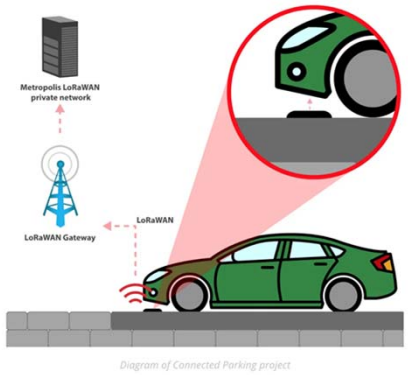
- congestion, pollution
- loss of productive time
- discontent and frustration

Need for Systems Engineering

Smart Parking:

- focus on technology
- localised solutions
- focus on drivers





- Needs of different stakeholders
- Integration with other smart city systems
- Scalability and inclusion
- Lock-in to proprietary systems

Objective

Define a reference architecture of a Smart Parking System

such that

- it enables advanced solutions based on parking data

while also

- defines guidelines for individual parties to provide their services
- ensures smooth integration of data and services
- allows phased adoption and scaling
- allows evolution based on varying needs and technological advancements

Understanding the context

Stakeholder & their needs

Drivers

- Convenience features
- Data Security
- Issue redressal
- Unified interface, but choice

Municipality

- Display status on road-signs
- Customer adoption
- Scalability and flexibility
- current & long term data

Smart Parking System

Law enforcement

- Track stolen vehicle

Parking lot owners

- Customer inflow
- Digitisation services
- Minimum investments

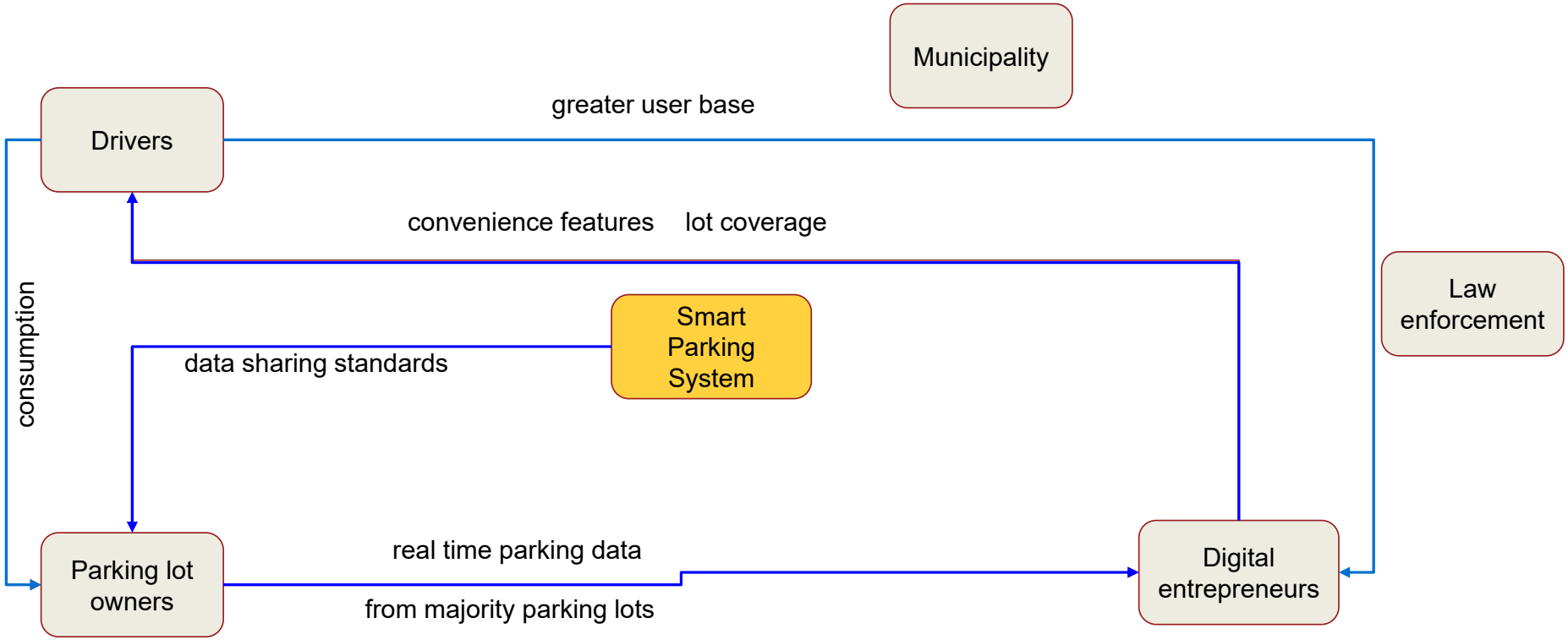
Digital entrepreneurs

- Standardised interface to data
- Scale and adoption

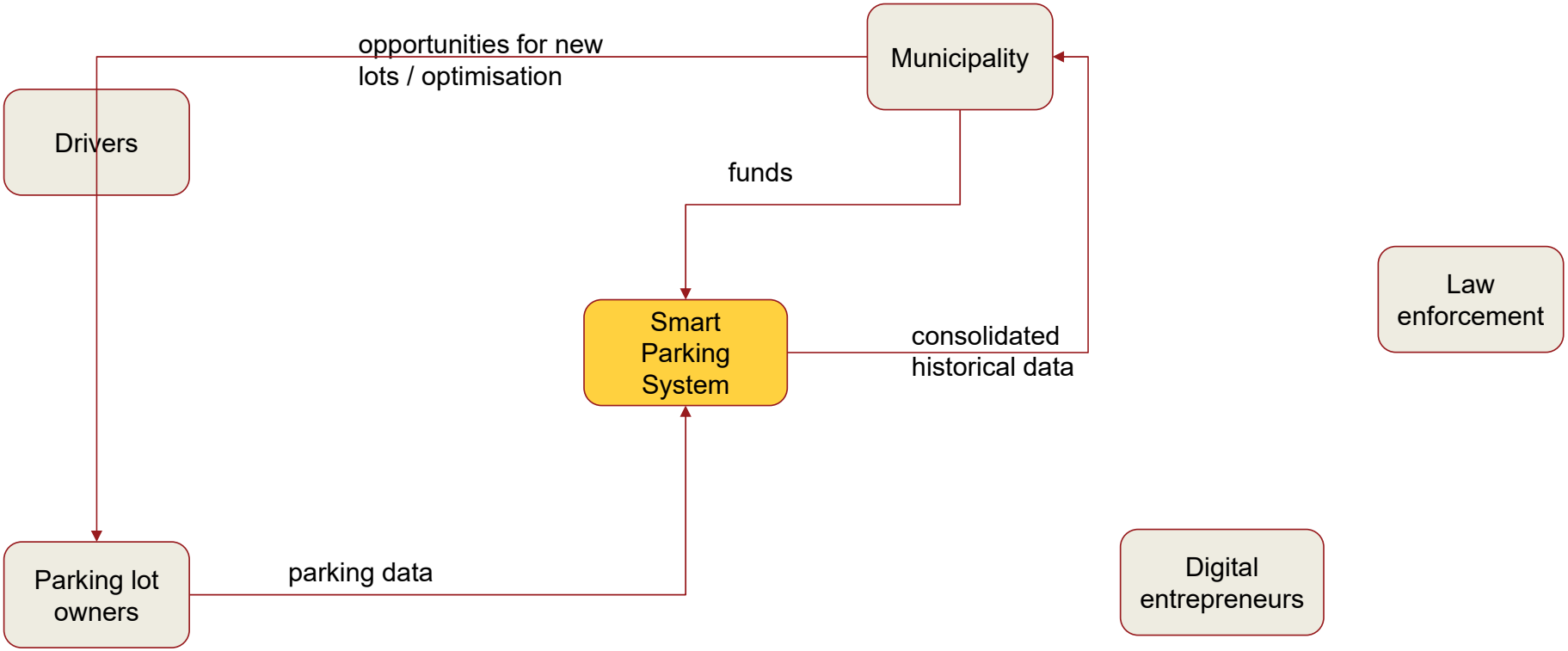
Prioritisation of needs

Stakeholder	Need	Priority
Drivers	Convenience features	9
Drivers	Choices for unified interface	8
Drivers	Data security	9
Municipality	Scalability and flexibility	8
Municipality	Consolidated trends from parking data	7
Parking lot owners	Minimum investments	8
Digital entrepreneurs	Standardised interface to data from all lots	9

Stakeholder value network

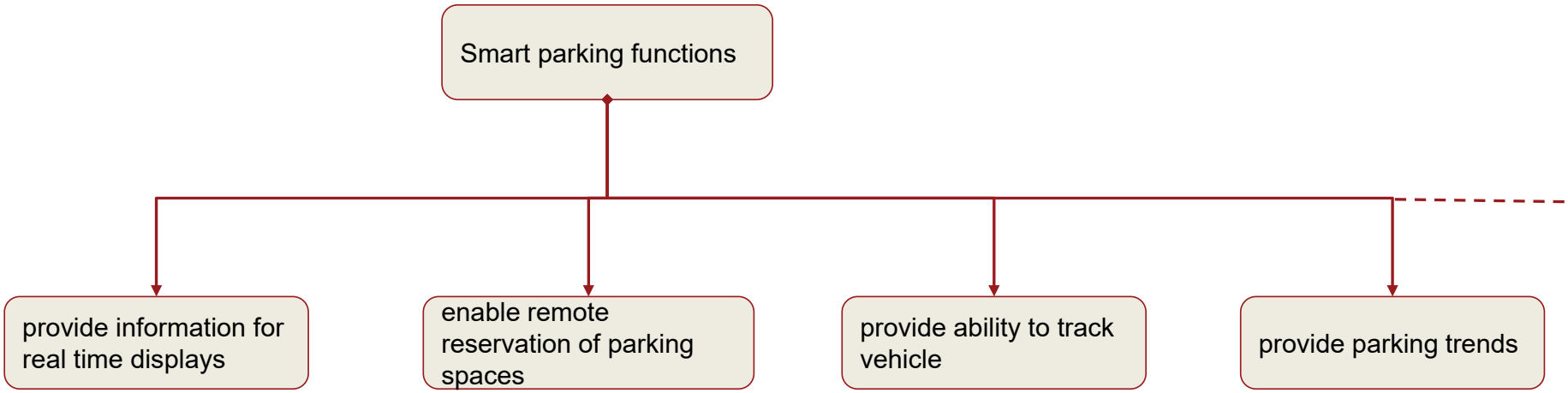


Stakeholder value network



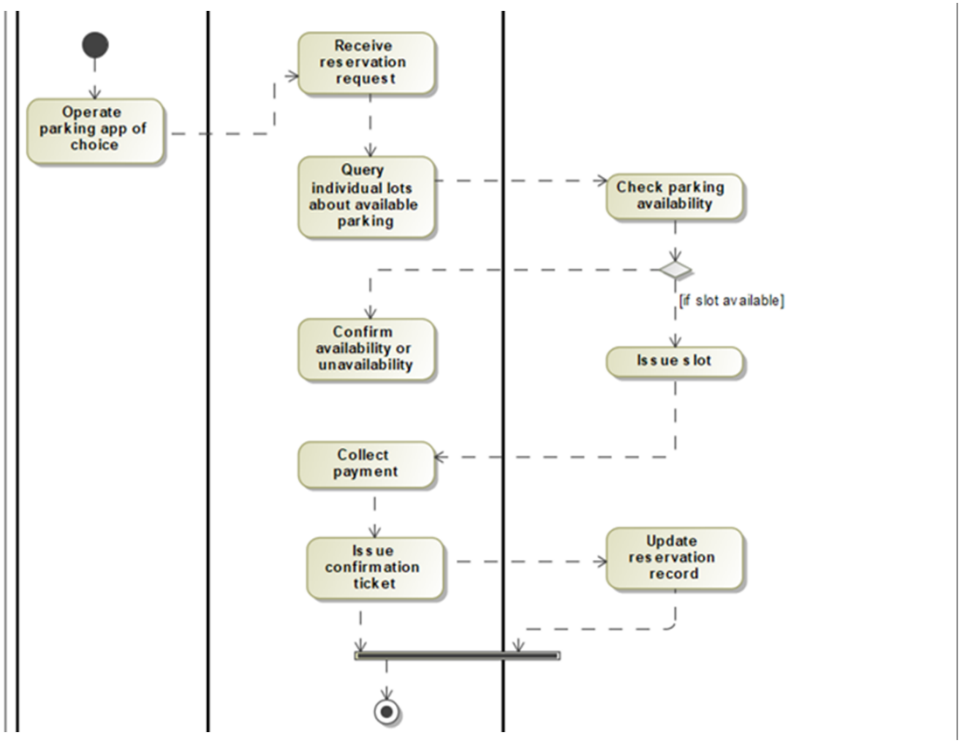
Developing alternate architectures

Functions of a Smart Parking System

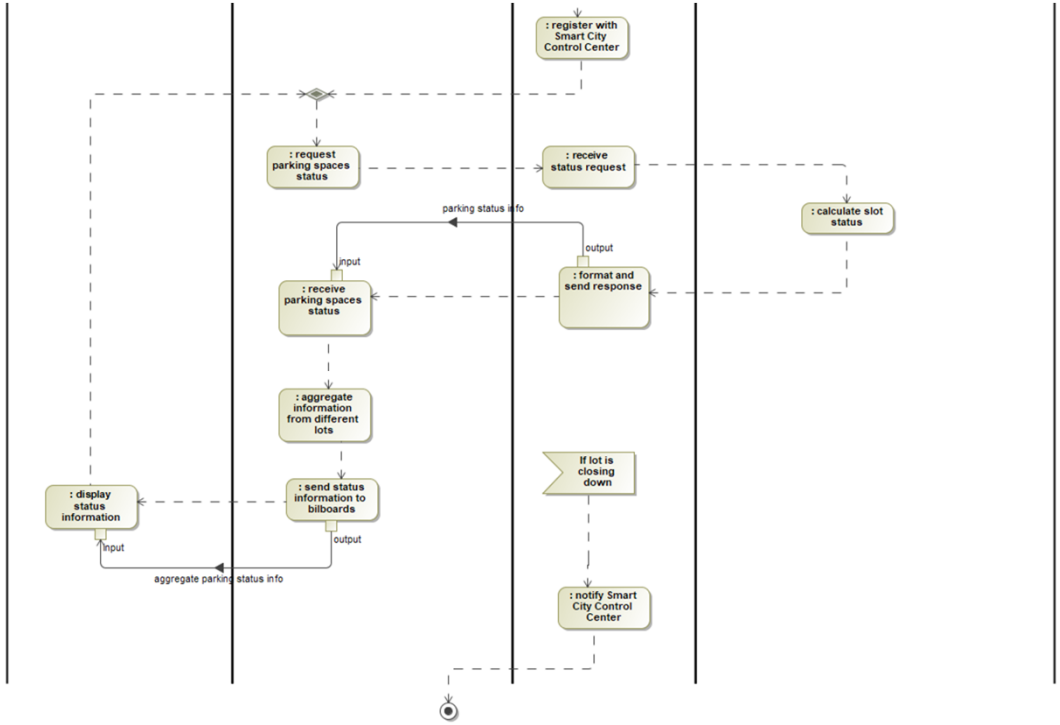


Functional flows

Reserving a parking space

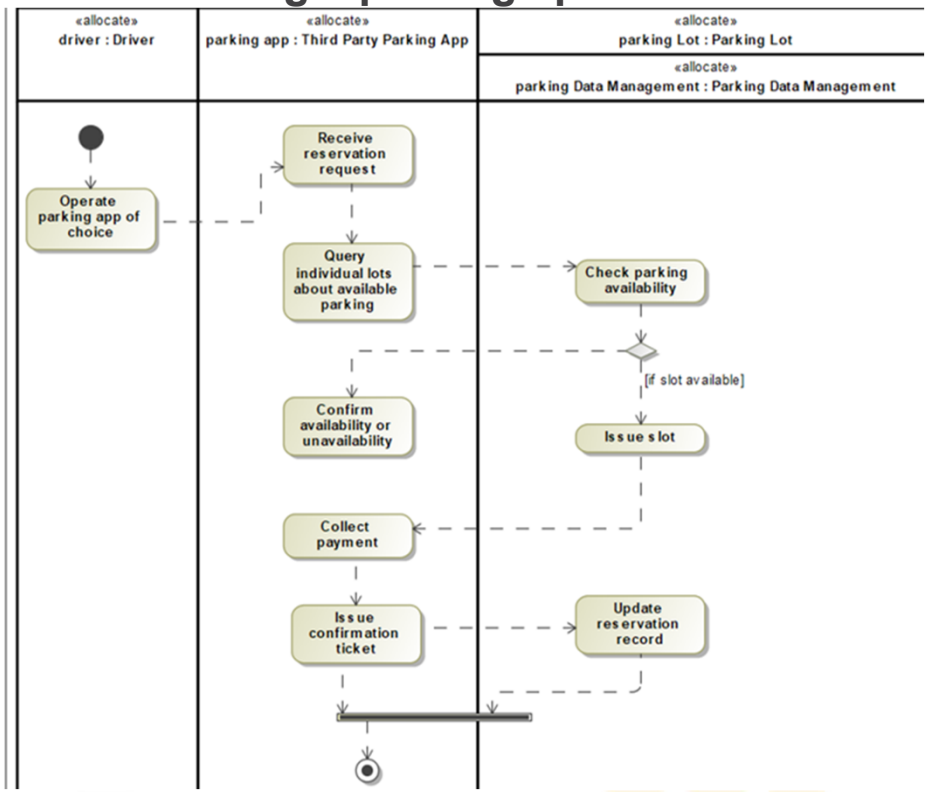


Showing availability on information displays



Form follows function

Reserving a parking space



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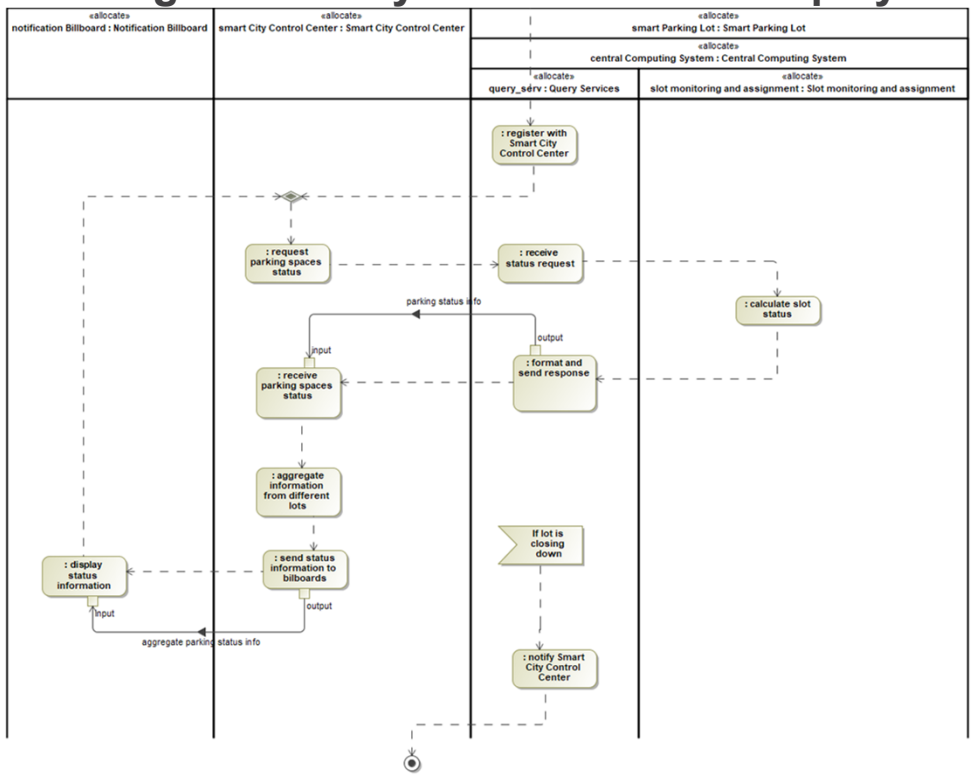
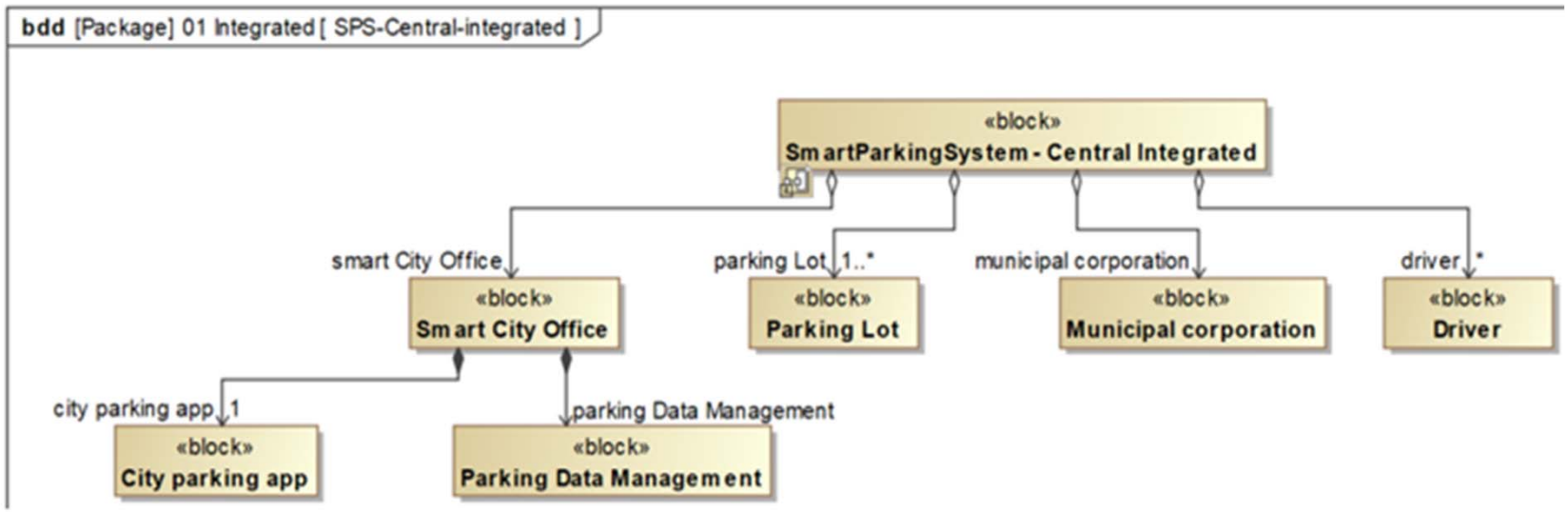


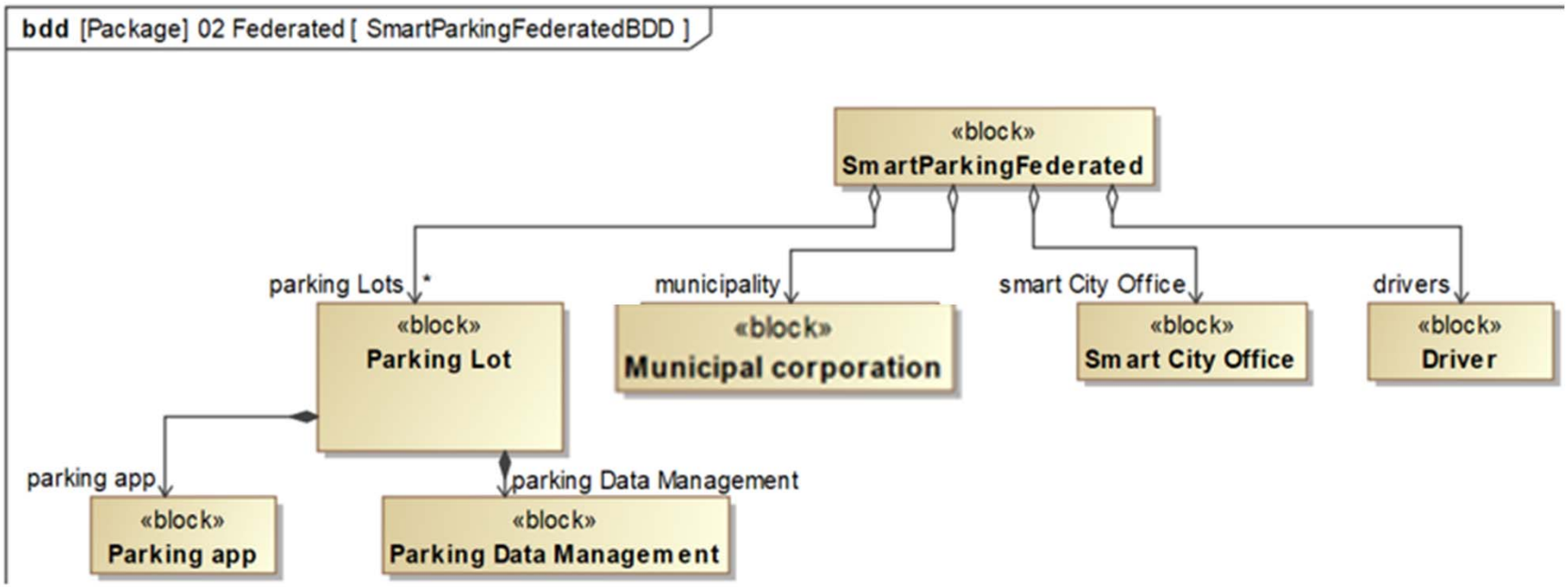
Architecture alternatives

Integrated



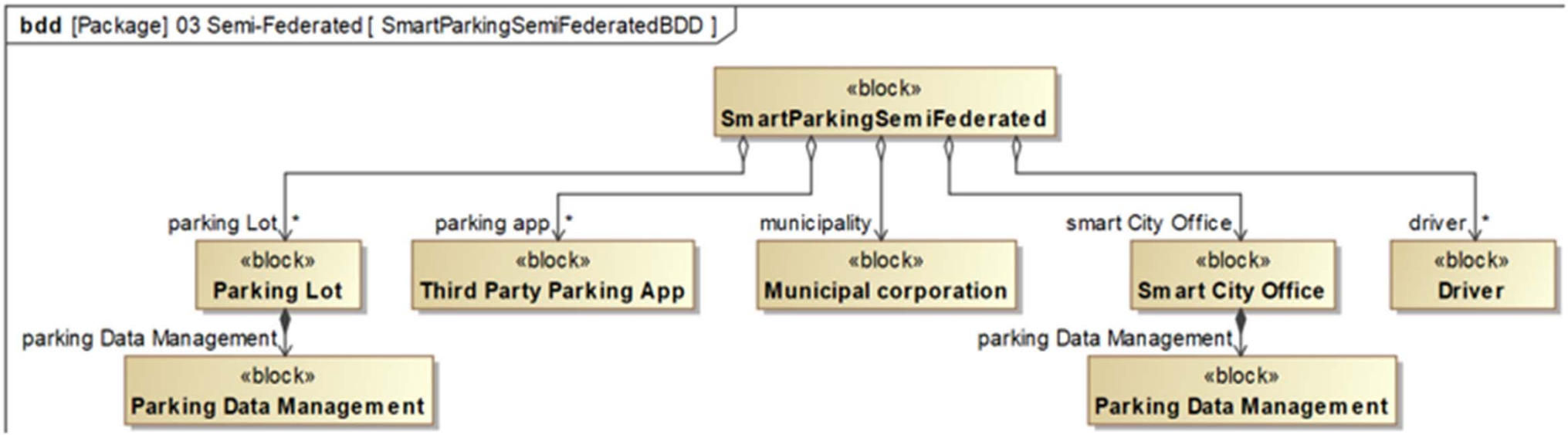
Architecture alternatives

Federated



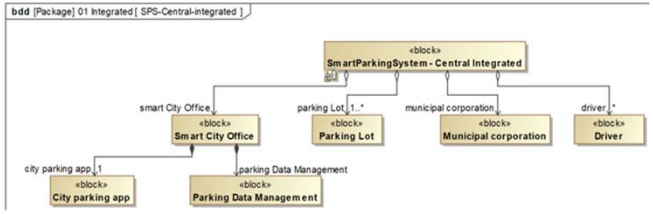
Architecture alternatives

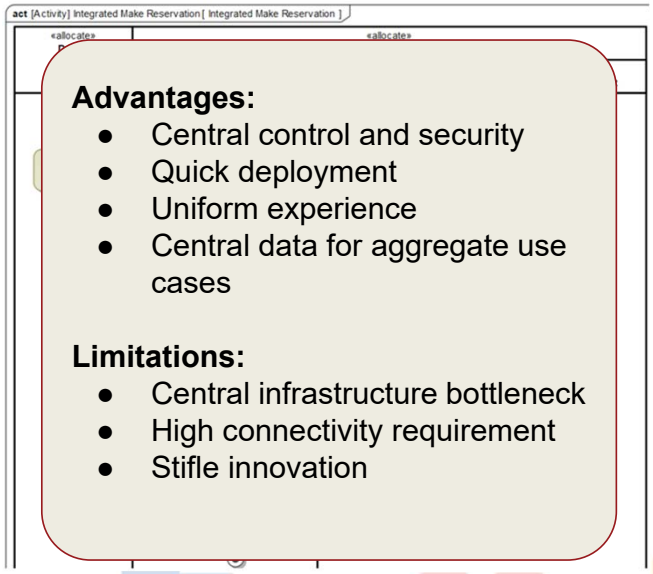
Semi-Federated



Architecture alternatives

Integrated





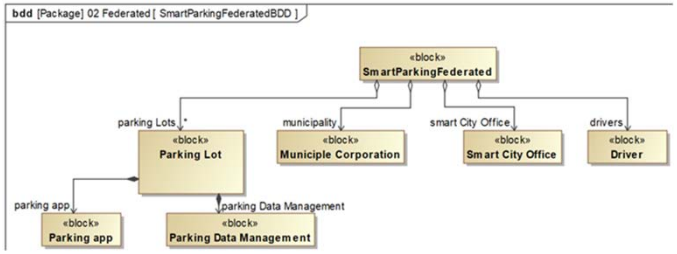
Advantages:

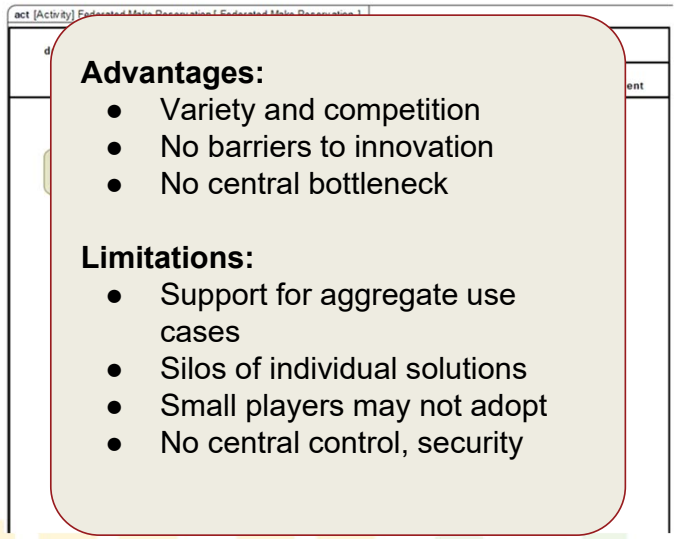
- Central control and security
- Quick deployment
- Uniform experience
- Central data for aggregate use cases

Limitations:

- Central infrastructure bottleneck
- High connectivity requirement
- Stifle innovation

Federated





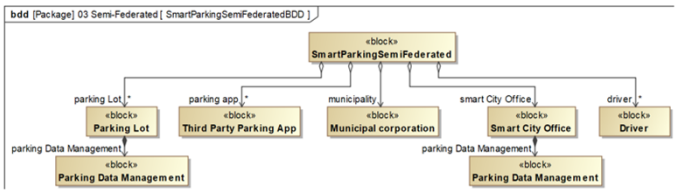
Advantages:

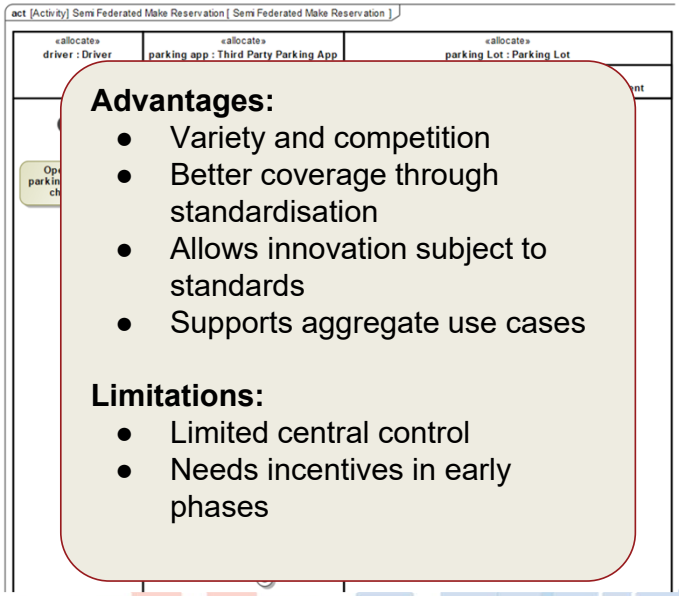
- Variety and competition
- No barriers to innovation
- No central bottleneck

Limitations:

- Support for aggregate use cases
- Silos of individual solutions
- Small players may not adopt
- No central control, security

Semi-Federated





Advantages:

- Variety and competition
- Better coverage through standardisation
- Allows innovation subject to standards
- Supports aggregate use cases

Limitations:

- Limited central control
- Needs incentives in early phases

Choosing an alternative

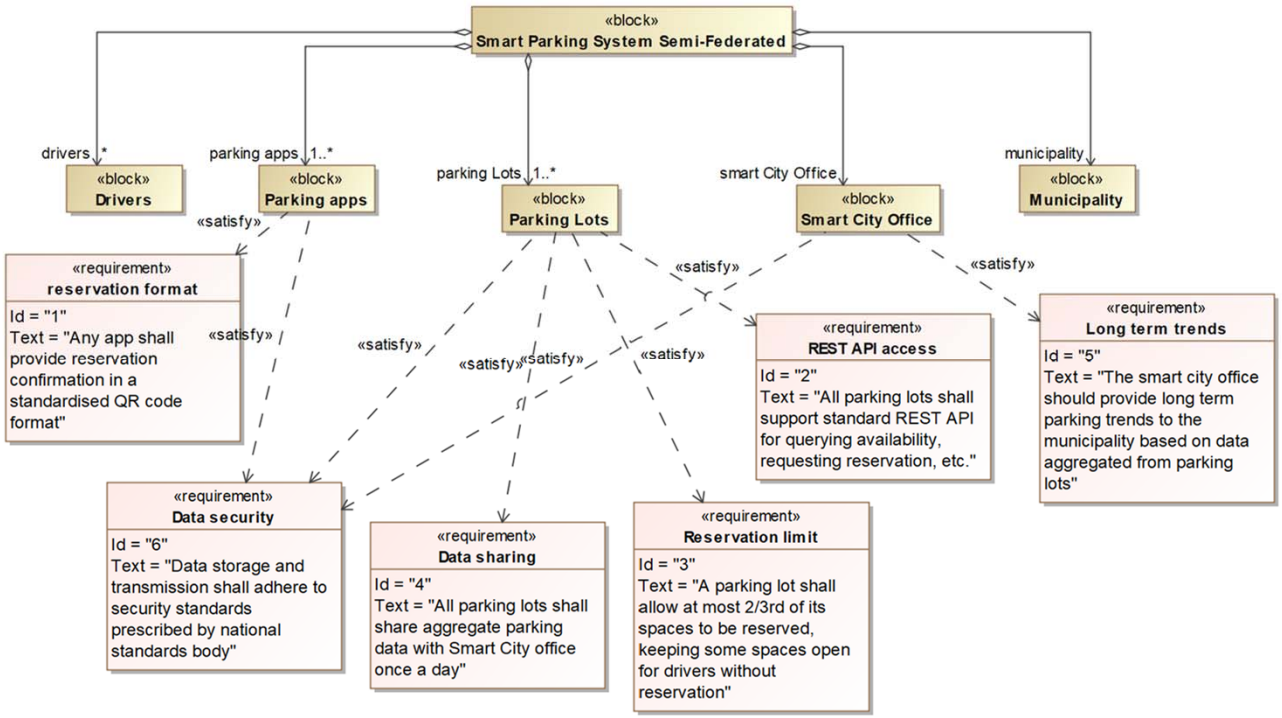
- Performance on identified priorities
- Suitability for context
- Alignment among stakeholders

Criteria (Stakeholder : need)	weight	Centrally operated		Federated		Semi-Federated	
		rating	*rationale*	*rating*	*rationale*	*rating*	*rationale*
Drivers: remote reservation	9	3	all lots covered in central system	1	only for lots providing smart features	2	any lots integrated into system - which might develop slowly
Drivers: availability tracking	8	3	central tracking	1	separate tracking for each lot	2	central tracking in app of choice, depends on app
Drivers: choice in modes interfaces of interaction	8	1	only one choice	1	choice linked to parking lot	3	all parking lots available through interface of choice
Drivers/residents: added features and services	6	1	depends on city app	1	dependent on individual parking lots	3	new services possible through entrepreneurs
Digital service providers/entrepreneurs:	9	1	depends on data sharing by city	1	need to partner with parking lots	3	allowed to operate independently in the
Parking lot owners: incentives for supporting smart features	8	1	access to drivers through central system	1	limited incentives for parking lots to provide additional smart features	3	can benefit from innovations in the ecosystem
Parking lot owners: differentiating features to attract drivers	1	0	bound to central system	3	independent to create their own system of smart features	1	limited by standards that must be supported
Parking lot owners: flexible levels of supporting smart features	8	1	bound by central system	2	flexibility, but driven by cost	3	flexibility to increase levels of support by leveraging the ecosystem
Net rating		**134**		**90**		**221**	

Specifying chosen alternative and validation

Specifying the chosen alternative

- Function allocations
- Interfaces and interface requirements
- Constraints and derived requirements

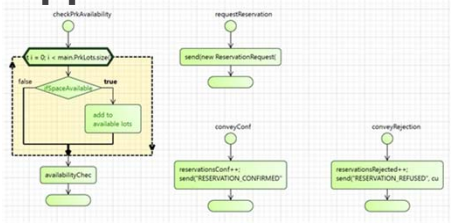


Sufficient guidelines for individual parties to build their sub-systems

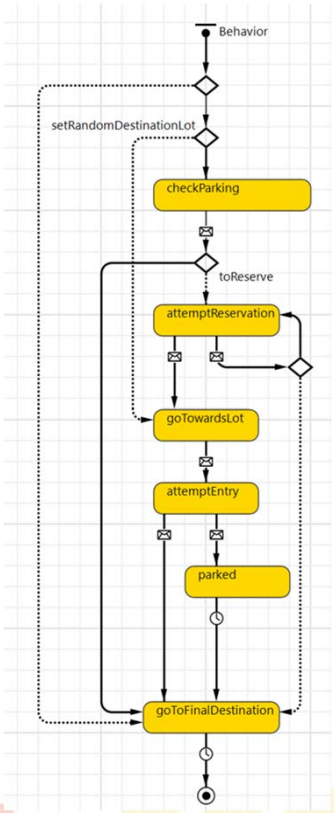
Agent Based Simulation for validation

Parking lot behavior

App behavior

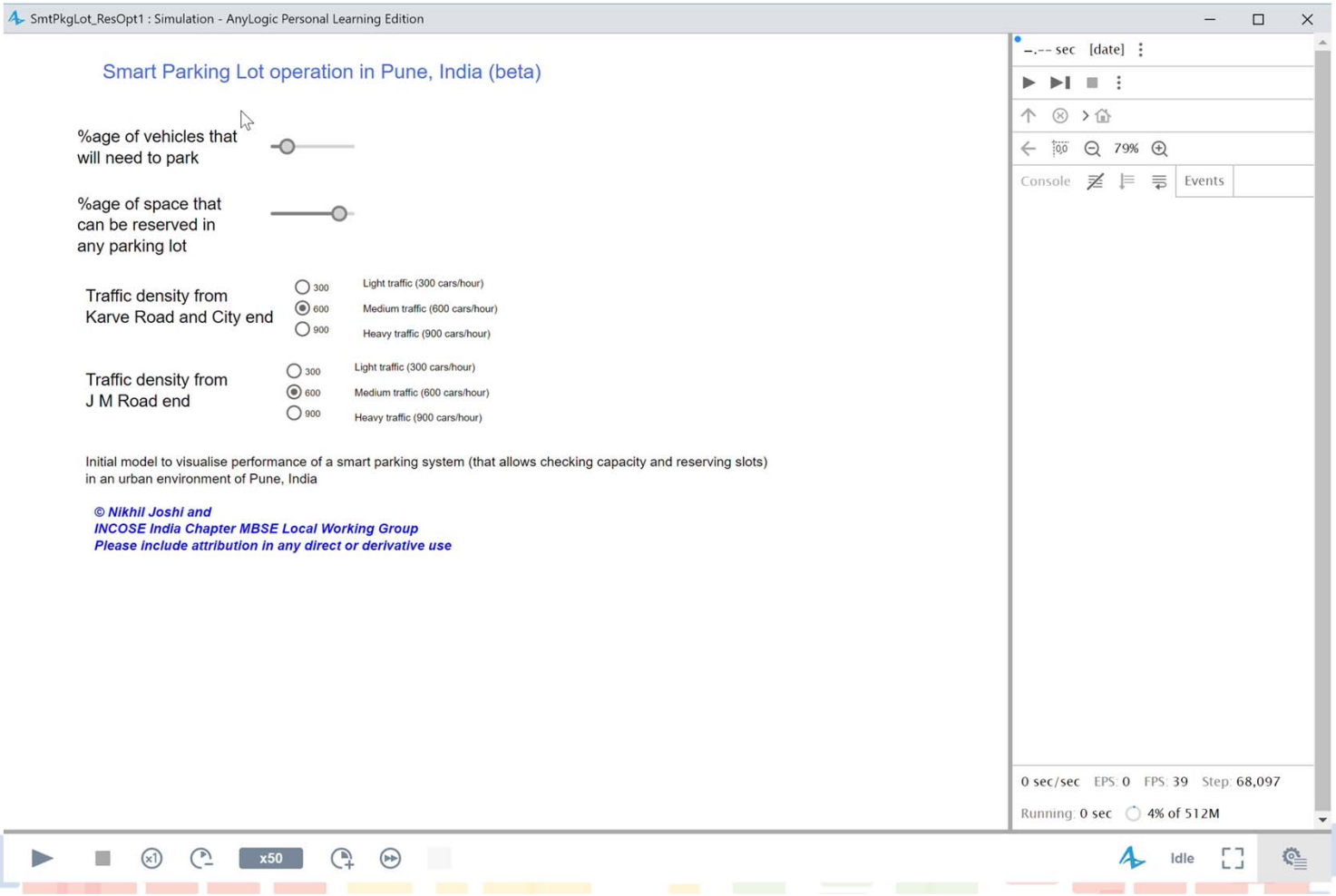


Driver behavior



Test scenario

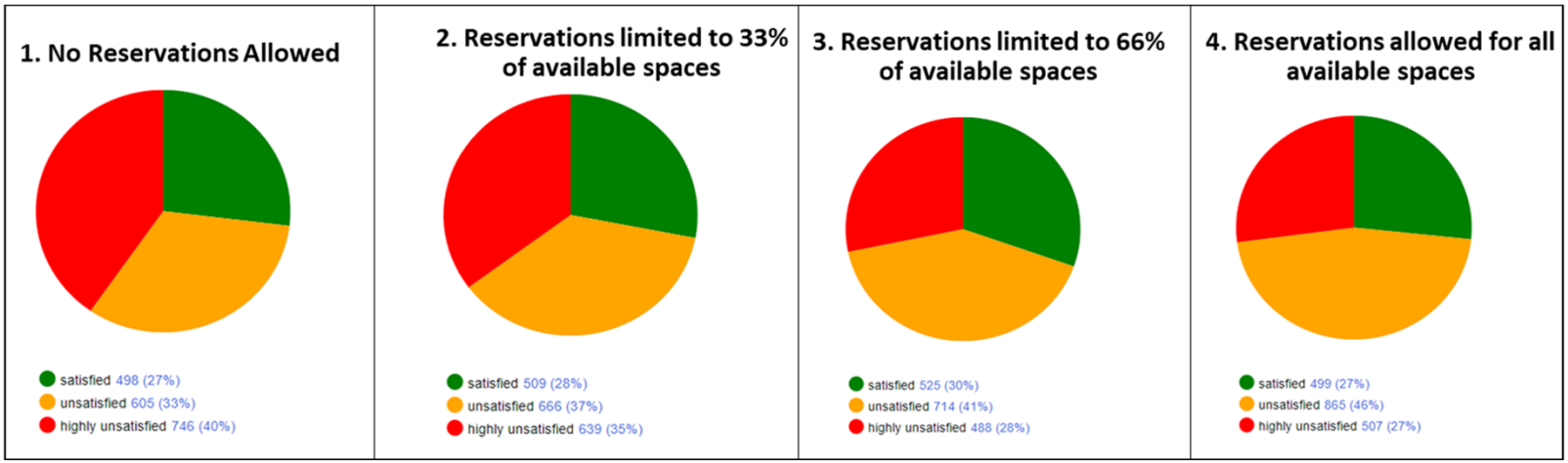
Simulating the model



Results and validation

- Satisfaction increases as Reservable spaces increase upto 66%
- Beyond 66% satisfaction stable or decreases

Validates chosen target for requirement



Conclusion

Summary

- Application of SE framework for social system architecture
- Captured stakeholders needs and context
- Analysed functional flows for different use cases
- Developed alternate architectures
- Elaborated chosen architecture with detailed requirements
- Developed simulation model to validate choice

Insights

- Formally approach and models ensure holistic solution
- Can avoid technology lock-in
- Simulation models provide valuable insights
- Can adapt and extend architecture
- Approach useful for such large scale, evolving, deployment of systems

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