Model-driven Development of Complex Routing Protocols with SDL-MDD

Alexander Geraldy, Reinhard Gotzhein, and Christoph Heidinger

Networked Systems Research Group

University of Kaiserslautern, Germany

Outline

- Context
- A generic routing protocol framework
- Design of ReBaC2/AodvLight
- Simulation results
- Conclusions

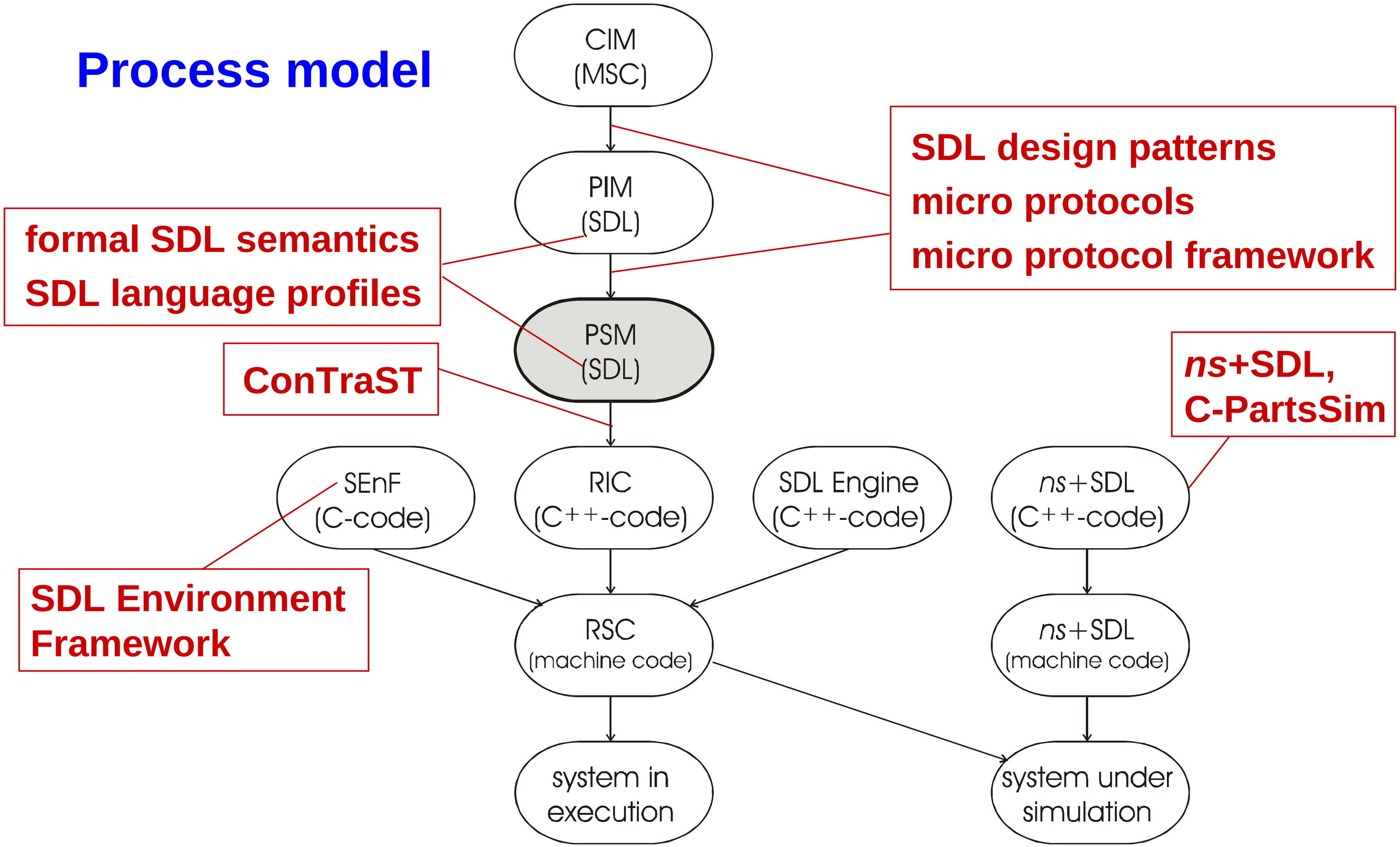
Context

- Model-driven development (MDD)
  - engineering approach where the formal model guides and directs all development activities
  - MDD activities range from system design over code generation and deployment to system maintenance.
  - MDD is a key approach to improving quality and productivity of system development.

- SDL-MDD
  - model-driven development with SDL as design language
  - addresses all phases of system development
  - supported by a semantically integrated and complete tool chain

Context

Process model



Context

- Complexity of routing protocols
  - different routing requirements (e.g., BE/QoS, proactive/reactive, …)
  - variety of address types (e.g., unicast, multicast, concast, anycast, broadcast, geocast, n-hop cast, …)
  - large variety of routing algorithms for each address type
  - different network types (e.g., wired/wireless, infrastructure-based/ ad-hoc, stationary/mobile, WAN/LAN, high-speed/field bus, dense/sparse, …)
  - optimization potential (e.g., hierarchical routing, adaptive routing, nested routing, …)

→ Composition of self-contained, elementary routing protocols

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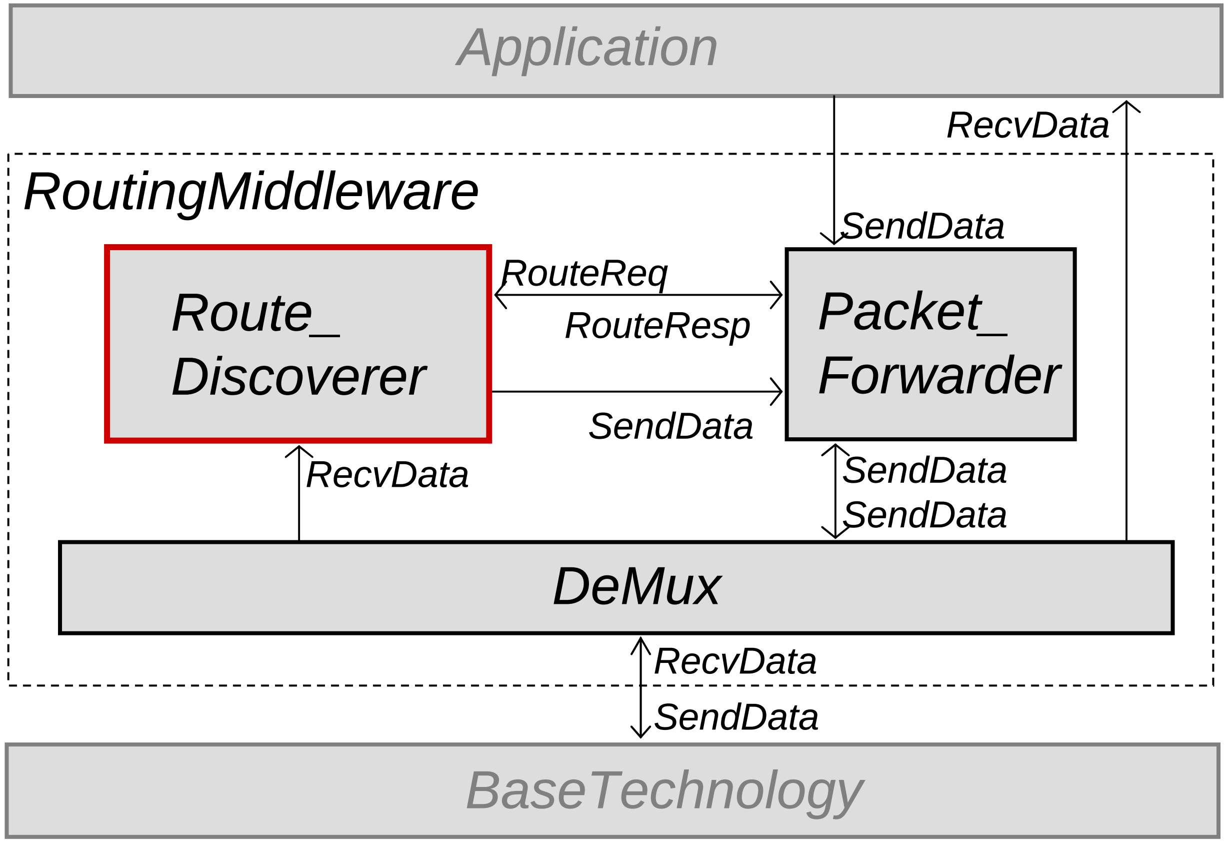
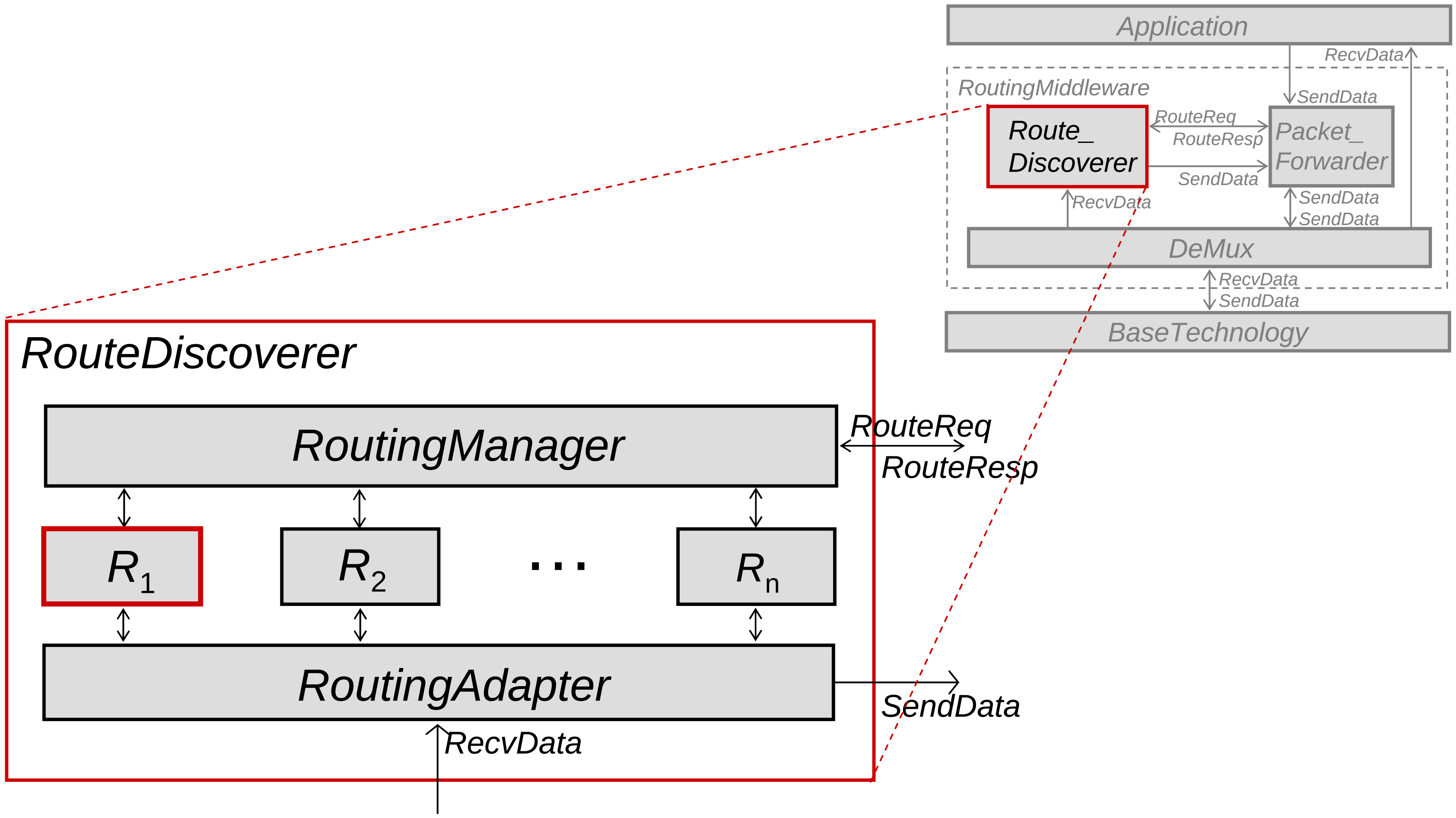
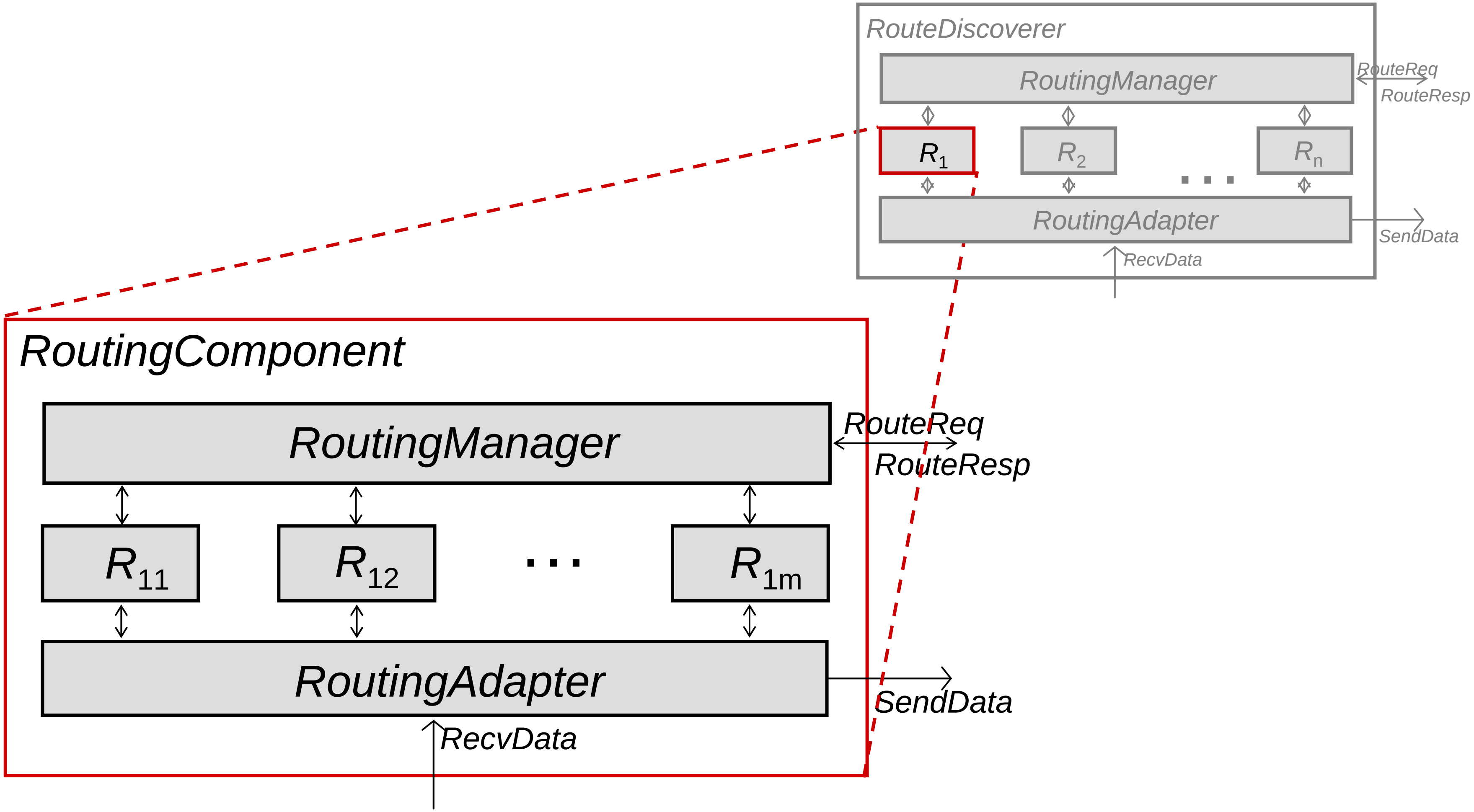
A generic routing protocol framework



A generic routing protocol framework



A generic routing protocol framework



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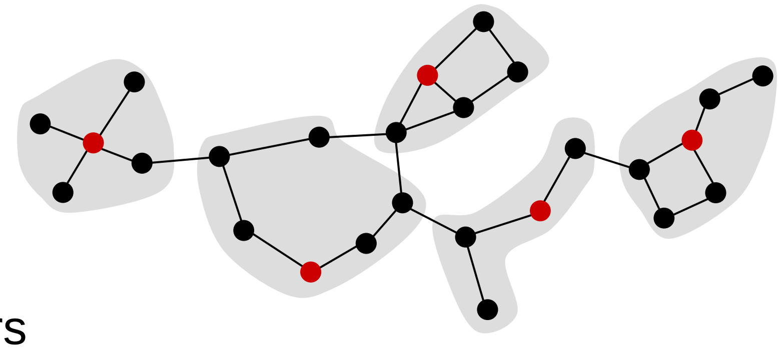
Design of ReBaC2/AodvLight

Clustering of mobile ad-hoc networks

- subdivide the network into sets of nodes called ***clusters***
- nodes of a cluster are ***cluster members***; there may be a distinguished ***cluster head***



- types of clusters
  - nodes with common parameters (e.g. small topological/geographical distance)
  - nodes with different capabilities (e.g. coordinator role, device role)
- hierarchical network topology → reduction of network complexity
- useful for efficient network management, hierarchical routing etc.

Design of ReBaC2/AodvLight

Repair-based Clustering (ReBaC2)

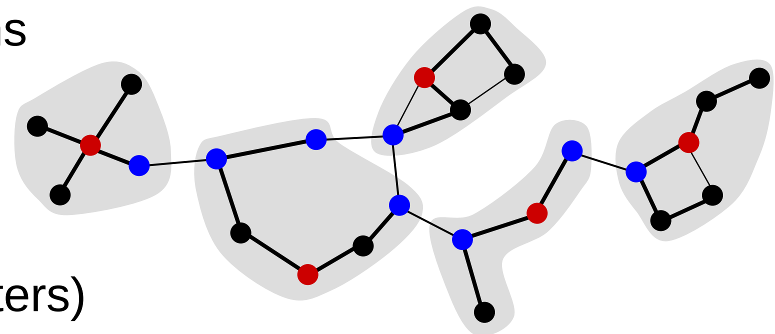
- dynamic, self-organizing process for network partitioning
- identical rules for cluster initialization and maintenance

  → graceful dynamic adaptation to topological changes

- modular clustering metrics (e.g. lower/upper bounds for cluster size, bounded cluster diameter, lower bound for link quality)

  → adaptation to specific network situations

- support for routing (logical tree structure of cluster members rooted at the cluster head, gateway nodes to neighboring clusters)

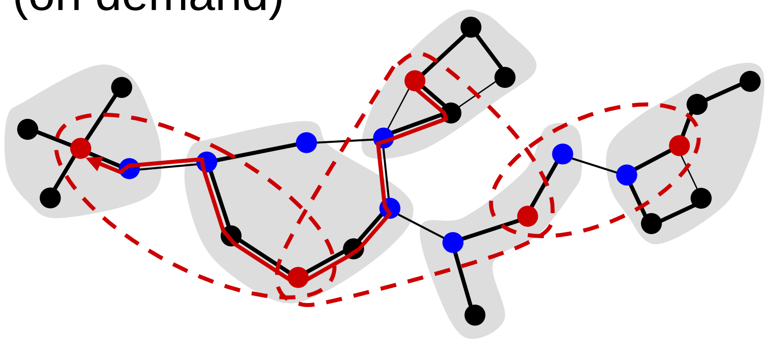


  → proactive collection of network status information during clustering

Design of ReBaC2/AodvLight

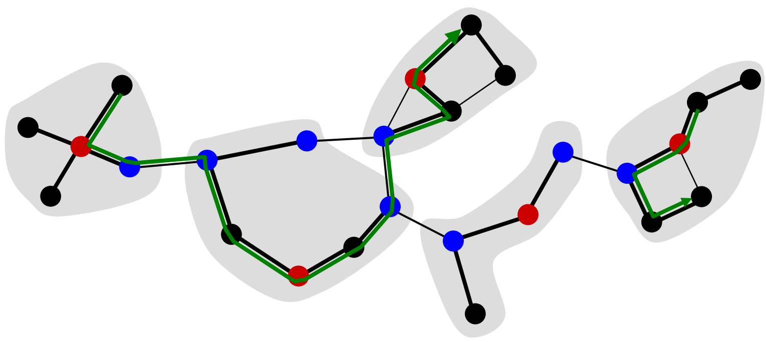
Ad-hoc On-demand Distance Vector Routing Light (AodvLight)

- reactive discovery of unidirectional routes (on demand)
- search by flooding of RREQ messages
- unidirectional response by RREPs



ReBaC2/AodvLight

- adaptive cluster establishment and maintenance
- proactive route discovery within clusters, based on tree structure
- reactive route discovery across clusters, by flooding RREQs to cluster heads



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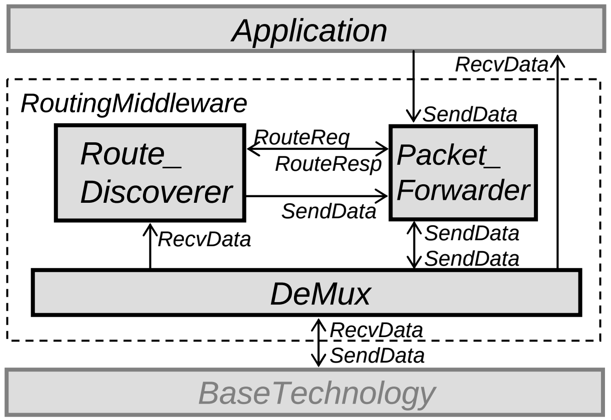

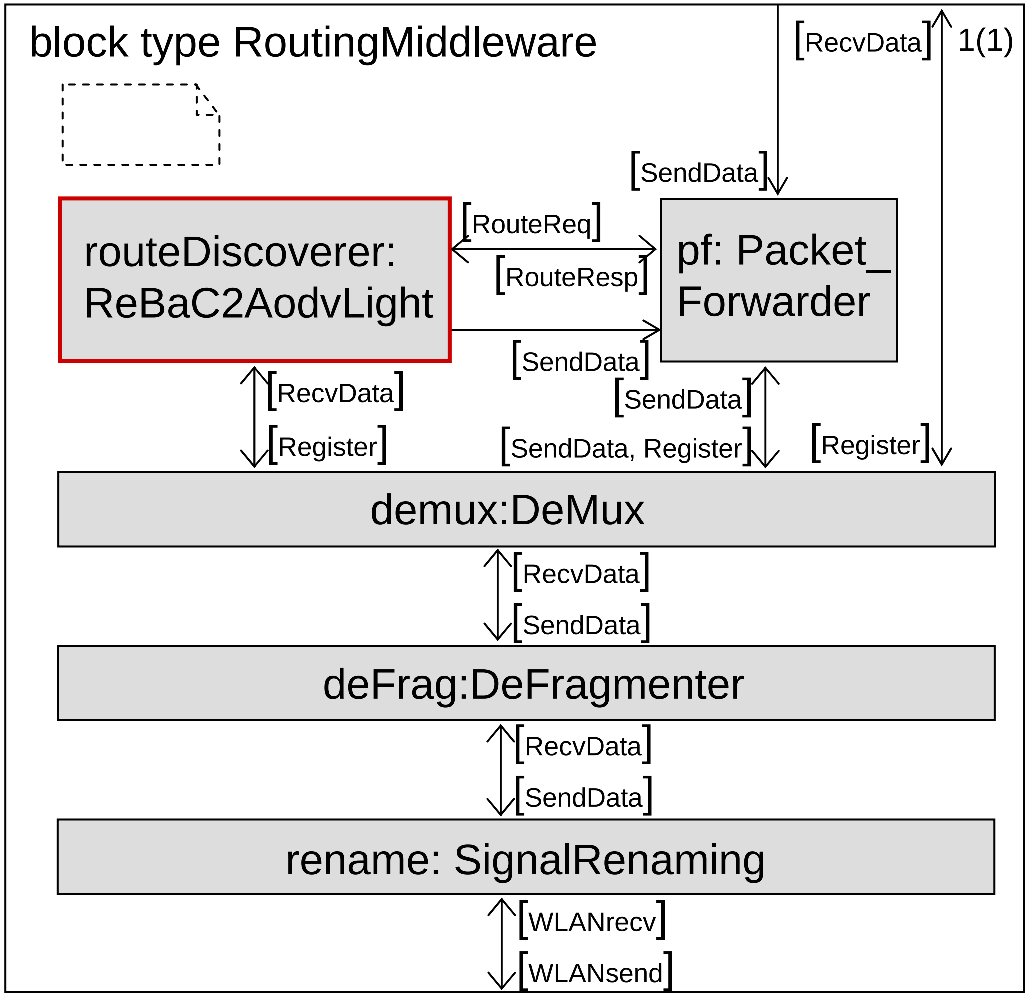

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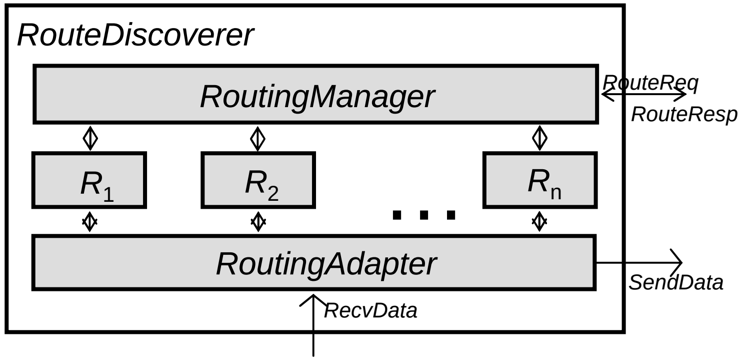

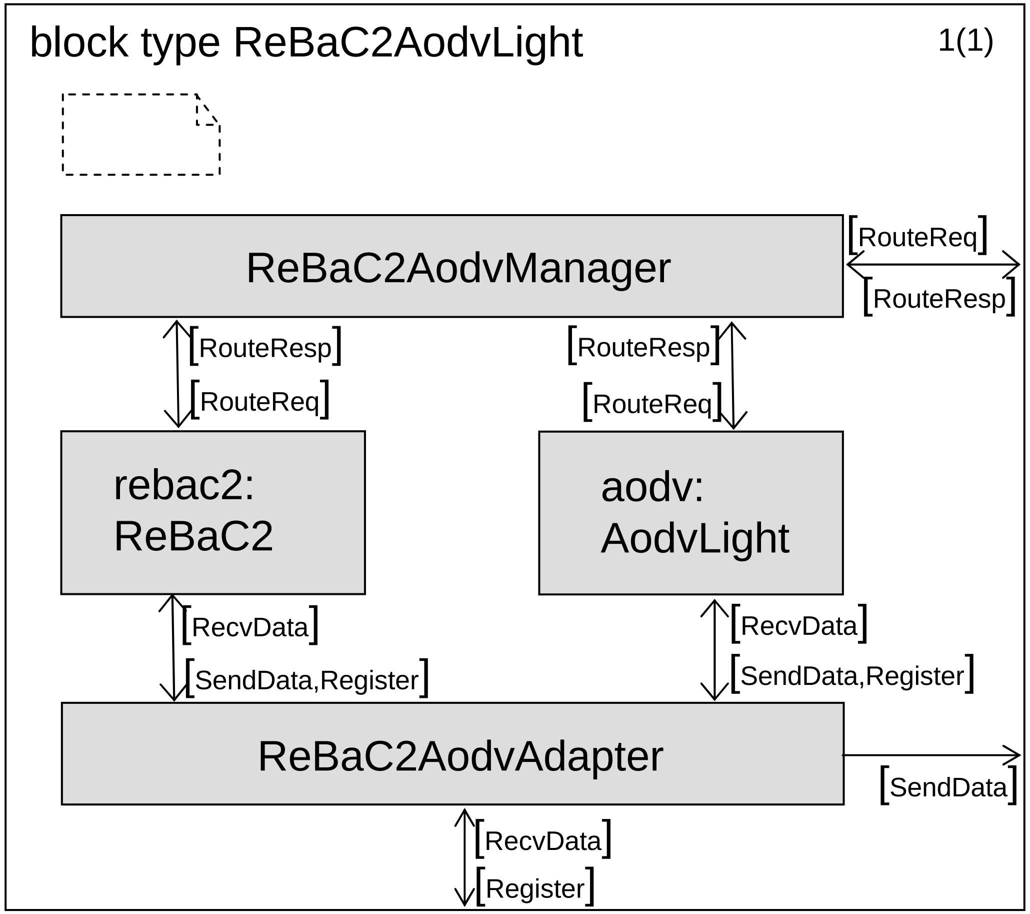

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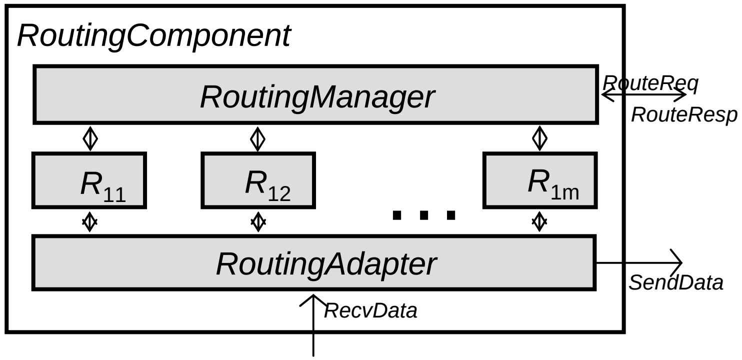

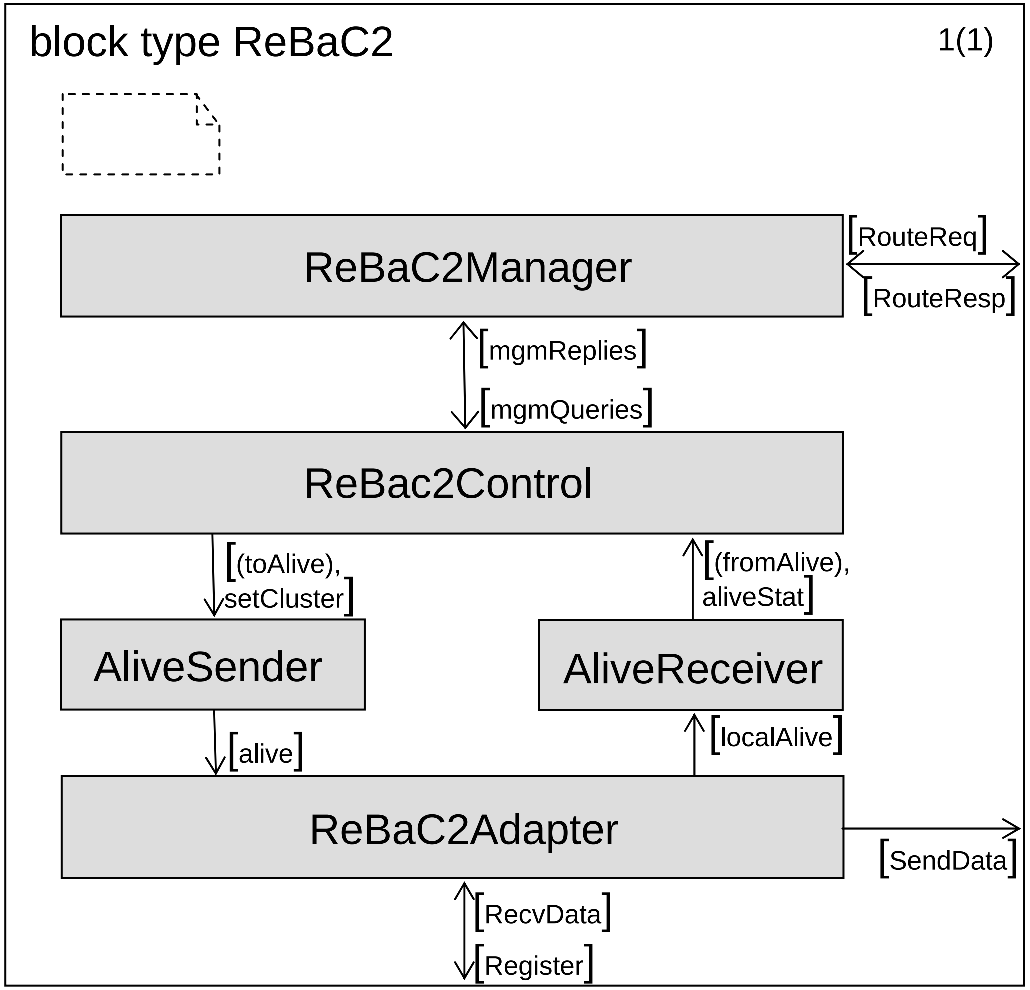

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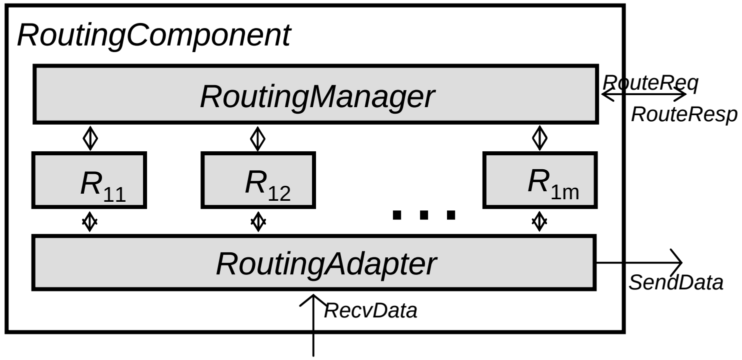

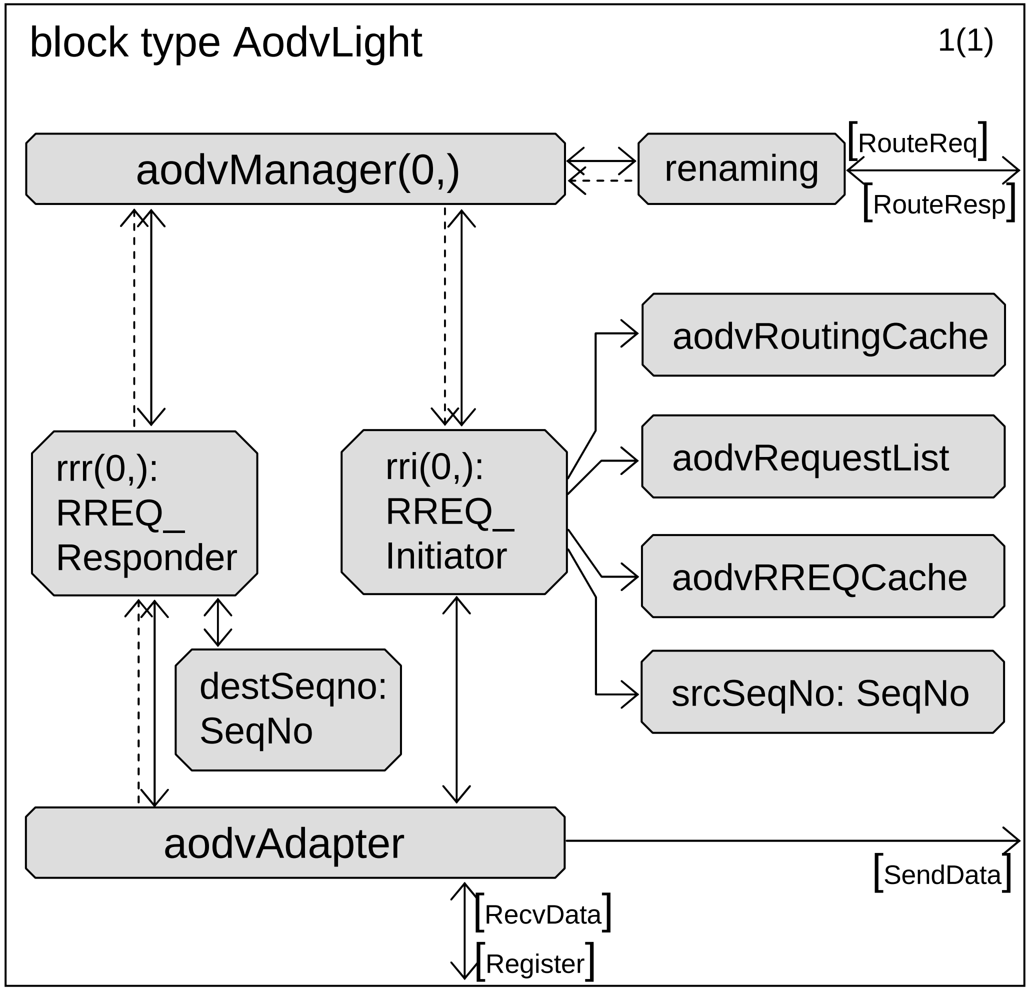

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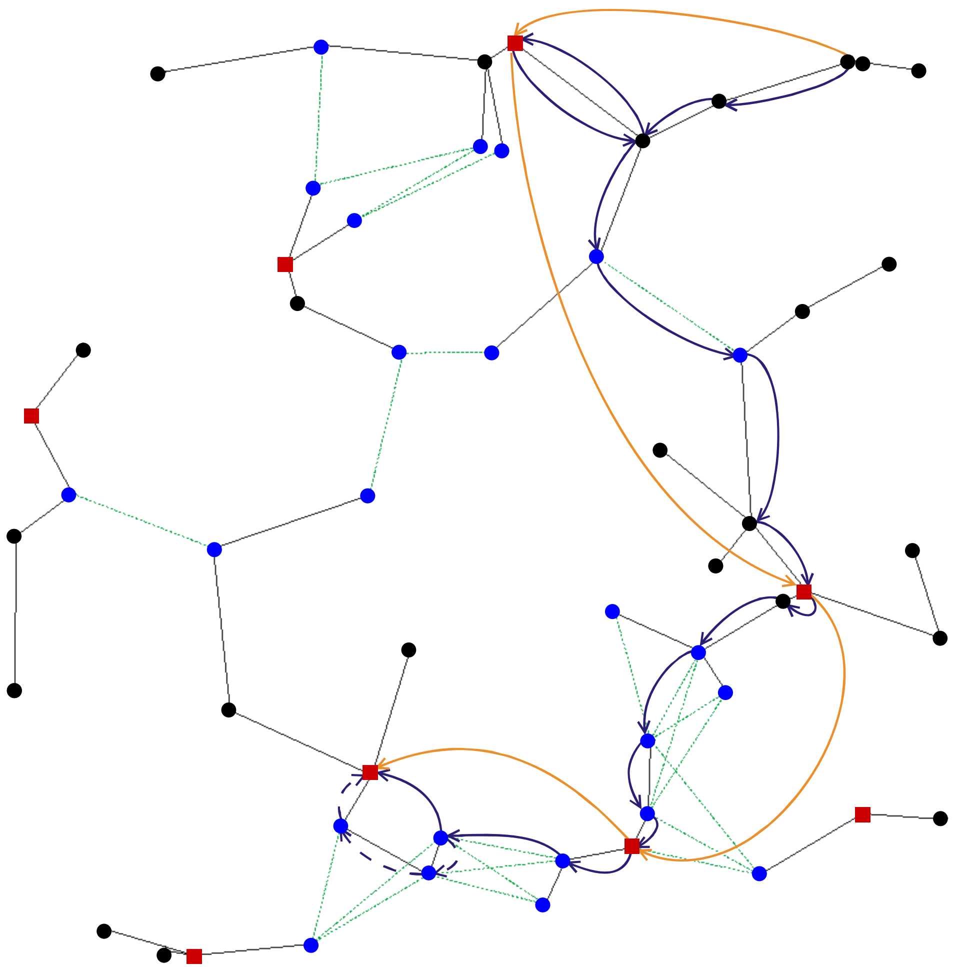
Simulation results



- 56 nodes, randomly placed
- 400x400m, tx range 73m
- cluster heads
- cluster links
- gateway links
- 8 clusters (size 3..13)
- max path length: 5 hops
- physical links
- overlay links

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Conclusions

- Model-driven development with SDL-MDD
  - applicable to complex routing protocols
  - tool chain fully operational and usable
- SDL sufficiently expressive, though not always elegant
  - self-contained and reusable micro protocol designs and components
  - complex routing architectures
  - “glue” for routing protocol composition
  - SDL representation of micro protocols depends on the intended composition
  - difficulties to find an adequate data representation for the generic addressing scheme (still SDL-96, due to available tool support)