IoT-DB-Simulator and Combining Query Processing with RPL-Routing

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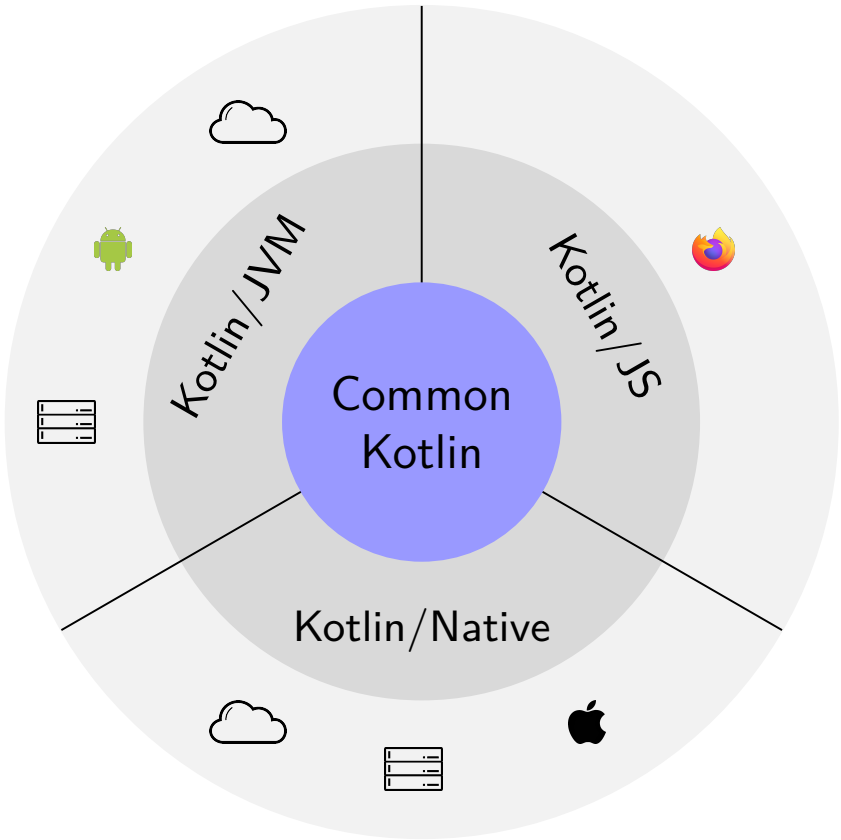
Kotlin

- young programming language (since 2011)
- focus on shared code across multiple platforms
- Kotlin native was revised recently



Luposdate3000

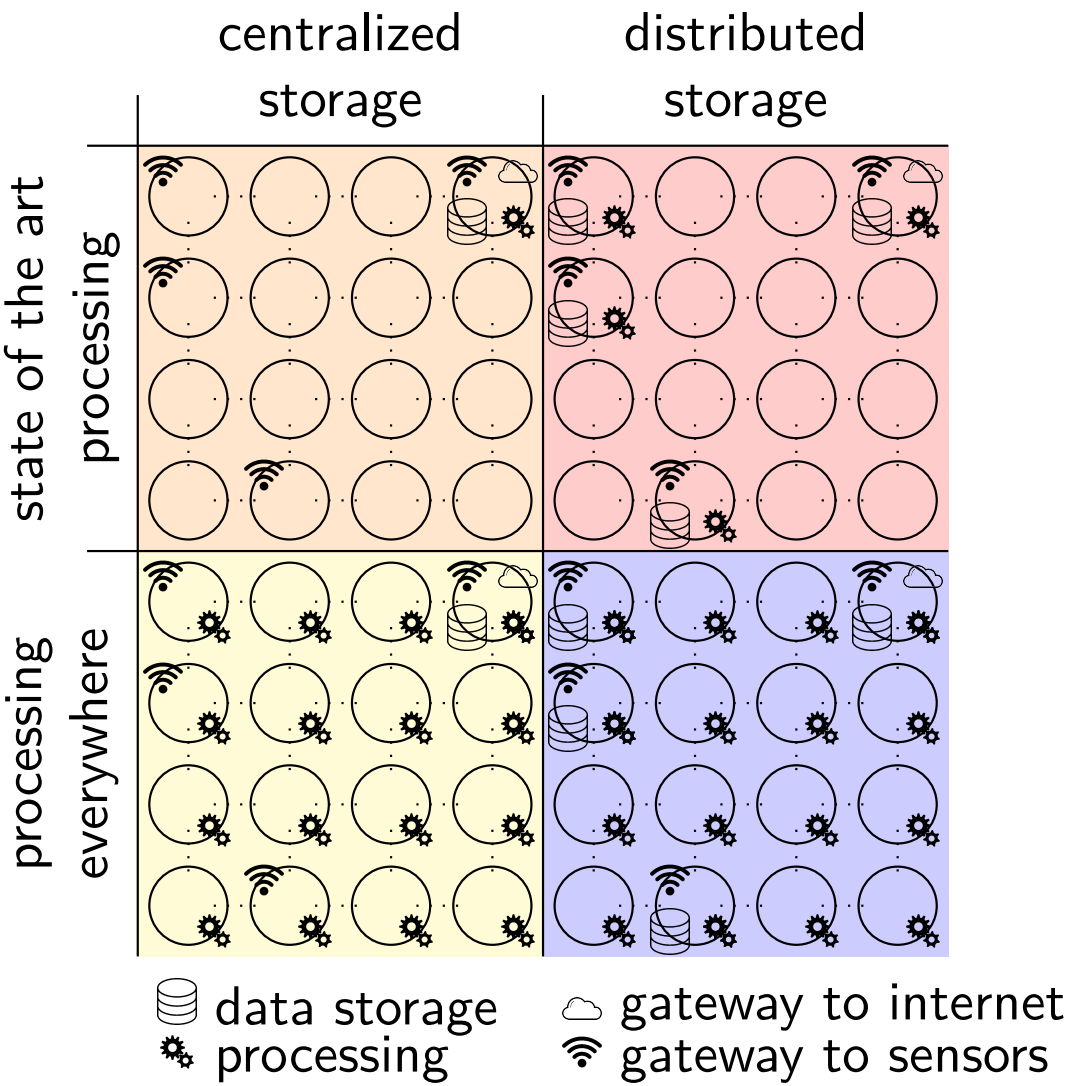
- luposdate3000 successor of luposdate
- written in Kotlin → multi platform
- triple store index layout configurable to (RDF3X, Hexastore)
- stores data similar to ID-Triple
- column iterators (and row iterators where needed)
- data-distribution by hashing
  - all constants
  - single variables
- dictionary
  - value ↔ ID
  - inline values
  - ontology & most recent cache
- source code at `https://github.com/luposdate3000/luposdate3000.git`
- web-demo at `https://www.ifis.uni-luebeck.de/~warnke/luposdate3000/index.html`

Simulator

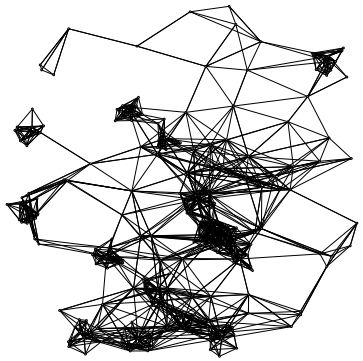
- called SIMORA (SIMulating Open Routing protocols for Application interoperability)
- written in Kotlin → multi platform
- event based
- focus on interoperability between routing and applications
- arbitrary number of (different) applications on each node
  - Database Instance
  - Sensor
  - Query

Simulator	Language	Routing Protocols	IoT Routing Protocols	Real Data	External Apps	cooperation between routing and application
CloudSim	Java					
COOJA	C, Java	✓0	✓0	✓1	✓1	
EdgeCloudSim	Java					
FogBed	Python			✓0	✓3	
FogNetSim++	C++	✓0				
iFogSim	Java					
IotSimEdge	Java	✓0				
IoTSim-Osmosis	Java	✓0				
Mininet	Python			✓0		
MyiFogSim	Java					
ns-3	C++, Python	✓1	✓1	✓1	✓2	
PureEdgeSim	Java					
YAFS	Python					
SIMORA	Kotlin	✓0	✓0	✓0	✓1	✓1

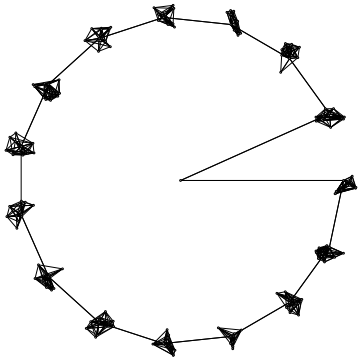
Figure: Feature comparison of network simulators. 0: without programming effort, 1: via interface, 2: via file descriptor, 3: via docker


centralized storage
distributed storage
state of the art processing
processing everywhere
data storage
processing
gateway to internet
gateway to sensors

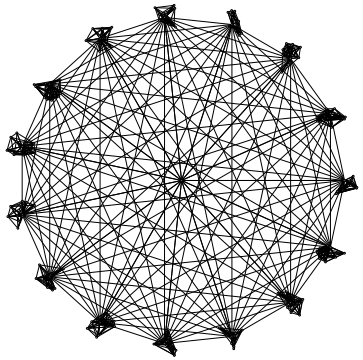
Benchmark Topologies



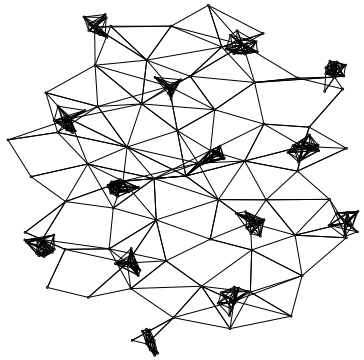
(a) Random



(b) Ring



(c) Full



(d) Uniform

insert $0 \rightarrow \{0, 3, 4, 13, 15\}$

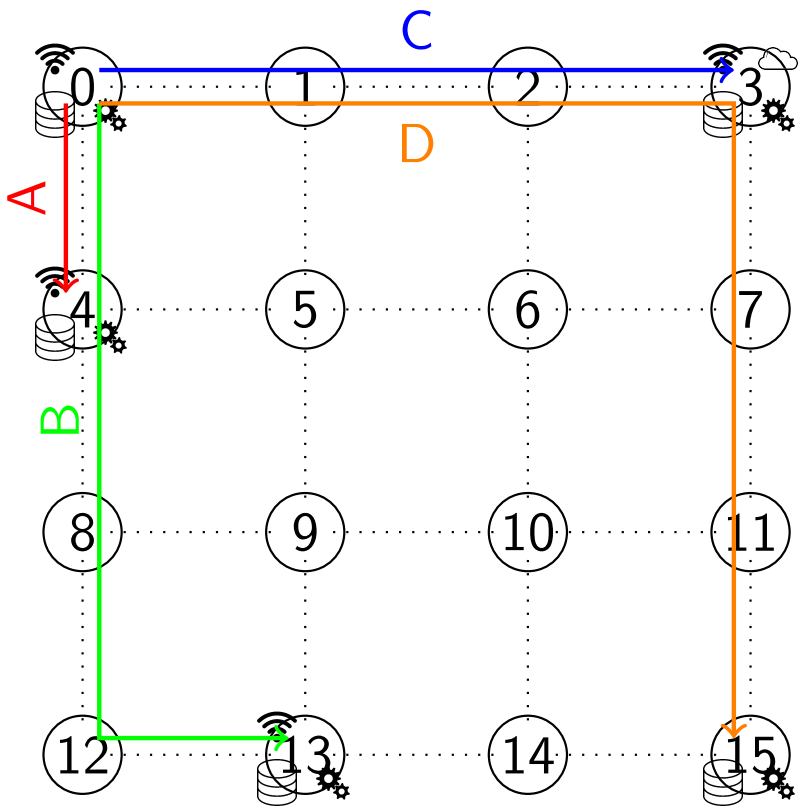


Figure: state of the art

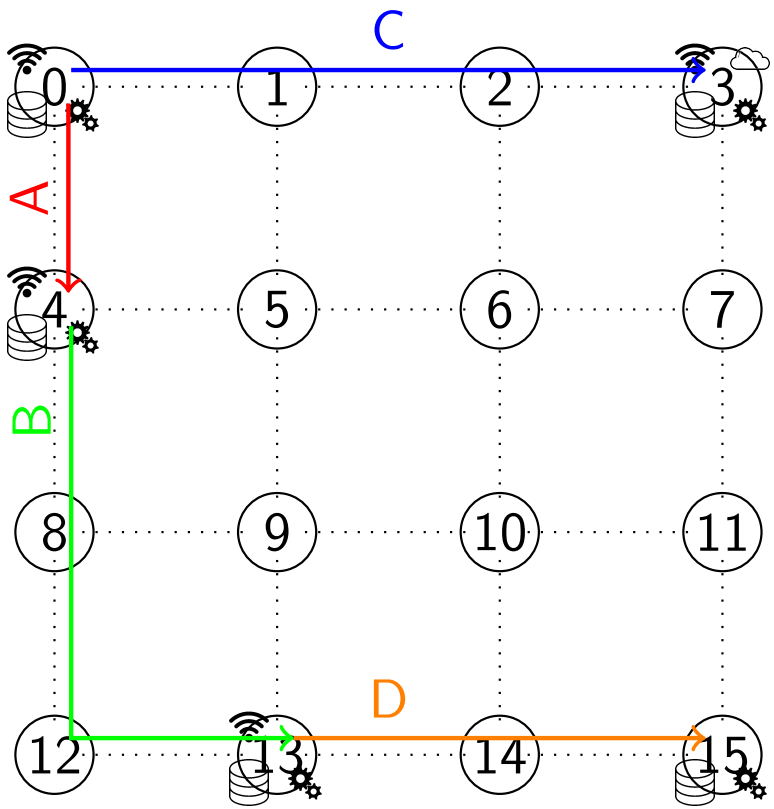


Figure: new possibilities

$4 \bowtie 13 \rightarrow 3$

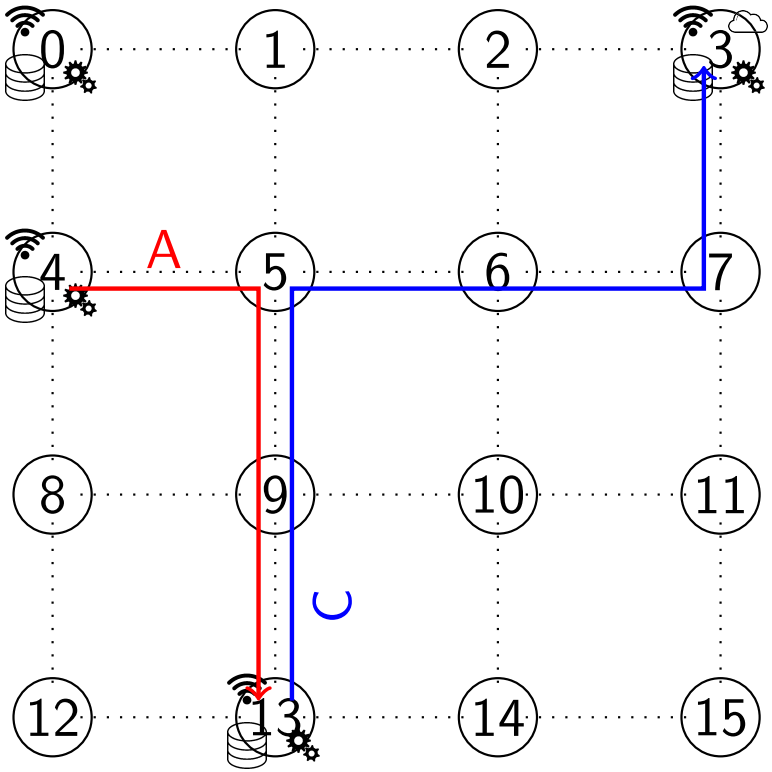


Figure: state of the art

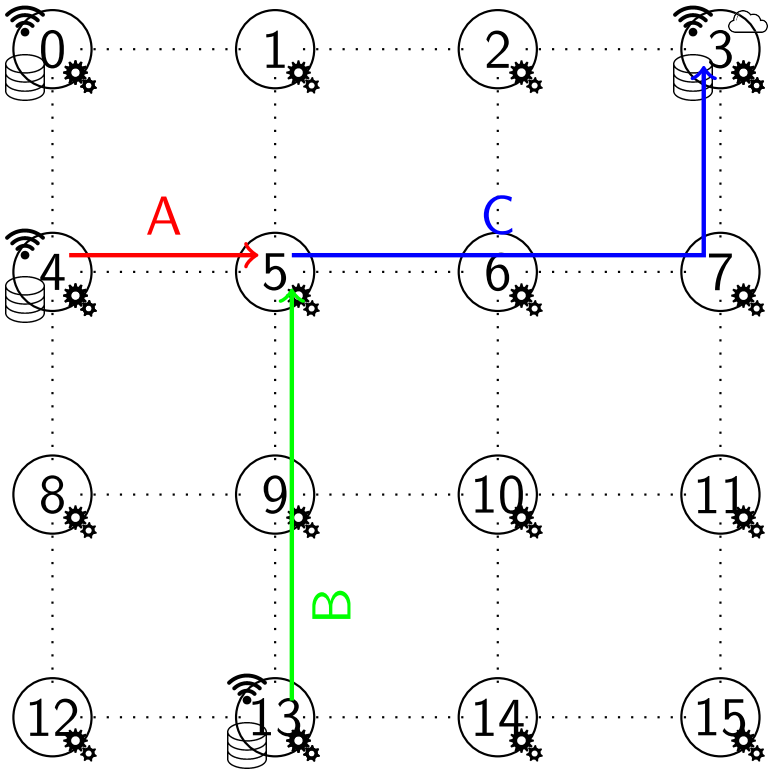


Figure: new possibilities

DBs	sensors	topology	devices	links	fill devices
4	30	ring4	34	162	0
		full4	34	164	0
		uniform4	48	200	14
		random4	54	377	20
16	150	ring16	166	742	0
		full16	166	846	0
		uniform16	219	926	53
		random16	245	1406	79
64	630	ring64	694	3047	0
		full64	694	4999	0
		uniform64	1532	5611	838
		random64	1951	9913	1257

network topology	ultra light database	data partition by	multicast	routing	number of packages	network traffic (Bytes)
Uniform	N	key	N	RPL	61979	15257002
Uniform	N	key	Y	RPL	27928	11641788
Uniform	N	subject	N	RPL	3293	349748
Uniform	N	subject	Y	RPL	3293	349748
Uniform	Y	key	N	RPL	62793	15891042
Uniform	Y	key	Y	RPL	27210	12153656
Uniform	Y	subject	N	RPL	8053	1970180
Uniform	Y	subject	Y	RPL	6151	5129356
Uniform	N	key	N	ASP	47882	11865451
Uniform	N	key	Y	ASP	37850	10755136
Uniform	N	subject	N	ASP	3208	346008
Uniform	N	subject	Y	ASP	3208	346008
Uniform	Y	key	N	ASP	47352	12131998
Uniform	Y	key	Y	ASP	30338	10187168
Uniform	Y	subject	N	ASP	6596	1624972
Uniform	Y	subject	Y	ASP	6740	2253250

Table: Measurement results, for topology with 16 full database instances each

network topology	ultra light database	data partition by	multicast	routing	number of packages	network traffic (Bytes)
Full	N	key	N	RPL	20874	4987035
Full	N	key	Y	RPL	11202	3837995
Full	N	subject	N	RPL	1530	130977
Full	N	subject	Y	RPL	1530	130977
Full	Y	key	N	RPL	20874	4987035
Full	Y	key	Y	RPL	11202	3837995
Full	Y	subject	N	RPL	1530	130977
Full	Y	subject	Y	RPL	1530	130977
Full	N	key	N	ASP	11202	2646747
Full	N	key	Y	ASP	11202	2646747
Full	N	subject	N	ASP	1530	130977
Full	N	subject	Y	ASP	1530	130977
Full	Y	key	N	ASP	11202	2646747
Full	Y	key	Y	ASP	11202	2646747
Full	Y	subject	N	ASP	1530	130977
Full	Y	subject	Y	ASP	1530	130977

Table: Measurement results, for topology with 16 full database instances each

network topology	ultra light database	data partition by	multicast	routing	number of packages	network traffic (Bytes)
Random	N	key	N	RPL	71020	17268514
Random	N	key	Y	RPL	32651	13486629
Random	N	subject	N	RPL	5114	456782
Random	N	subject	Y	RPL	5114	456782
Random	Y	key	N	RPL	71702	18082086
Random	Y	key	Y	RPL	31495	14066685
Random	Y	subject	N	RPL	10400	2391442
Random	Y	subject	Y	RPL	8369	6025816
Random	N	key	N	ASP	38701	9631726
Random	N	key	Y	ASP	33454	9049039
Random	N	subject	N	ASP	3509	386162
Random	N	subject	Y	ASP	3509	386162
Random	Y	key	N	ASP	39182	10277145
Random	Y	key	Y	ASP	27812	8914503
Random	Y	subject	N	ASP	6396	1634229
Random	Y	subject	Y	ASP	6504	2108159

Table: Measurement results, for topology with 16 full database instances each

network topology	ultra light database	data partition by	multicast	routing	number of packages	network traffic (Bytes)
Ring	N	key	N	RPL	59438	14648667
Ring	N	key	Y	RPL	14529	11490056
Ring	N	subject	N	RPL	4029	448854
Ring	N	subject	Y	RPL	4029	448854
Ring	Y	key	N	RPL	59438	14648667
Ring	Y	key	Y	RPL	14529	11490056
Ring	Y	subject	N	RPL	4029	448854
Ring	Y	subject	Y	RPL	4029	448854
Ring	N	key	N	ASP	45638	11298231
Ring	N	key	Y	ASP	15149	7824024
Ring	N	subject	N	ASP	4029	448854
Ring	N	subject	Y	ASP	4029	448854
Ring	Y	key	N	ASP	45638	11298231
Ring	Y	key	Y	ASP	15149	7824024
Ring	Y	subject	N	ASP	4029	448854
Ring	Y	subject	Y	ASP	4029	448854

Table: Measurement results, for topology with 16 full database instances each

Summary

- state of the art database does not care about network layout
- network traffic reduction during insert by using
  - RPL → ASP 17-48%
  - multi-cast 24%
  - additional devices 3%