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VANET Simulations with JiST/ SWANS

SEVECOM Kick-off Workshop

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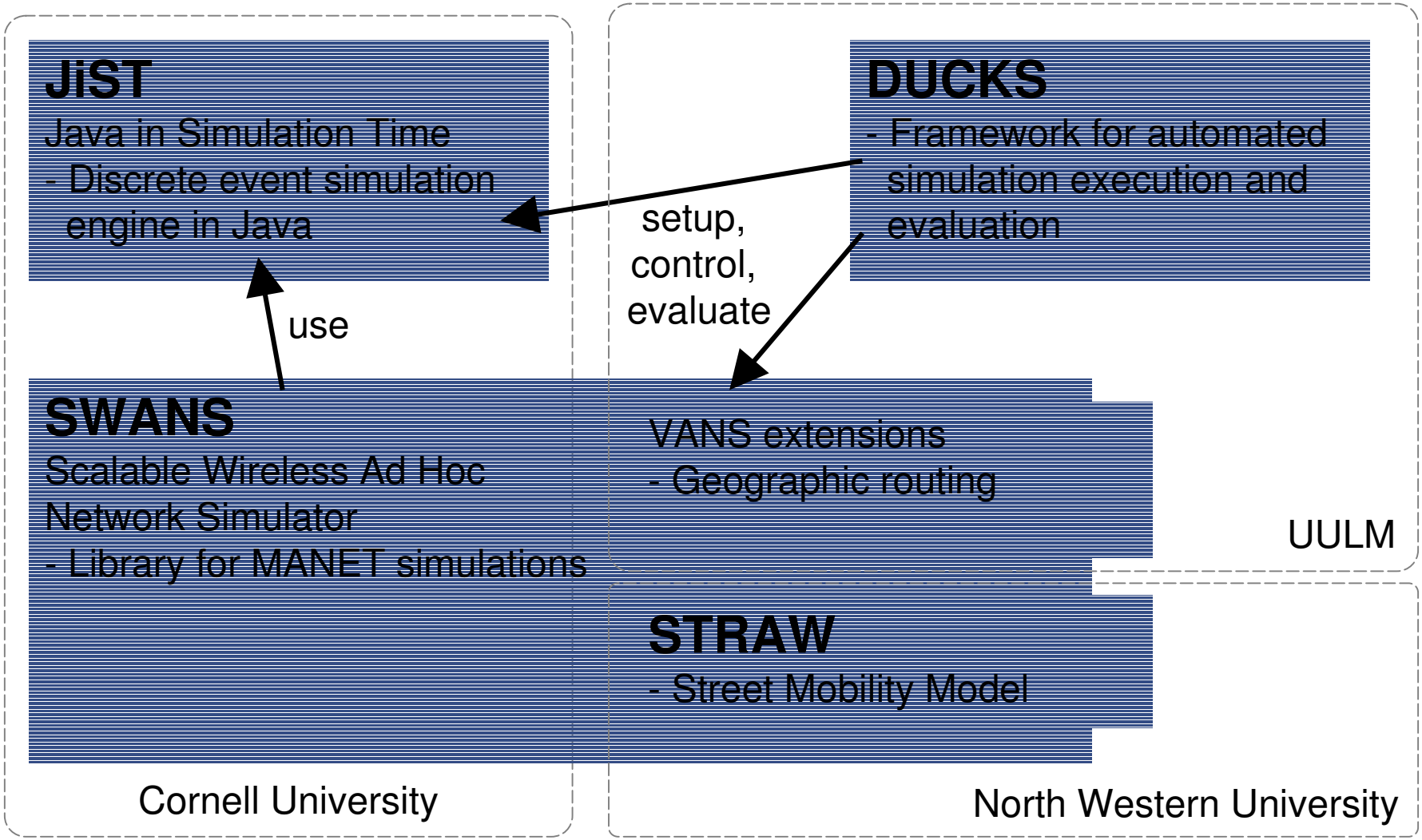
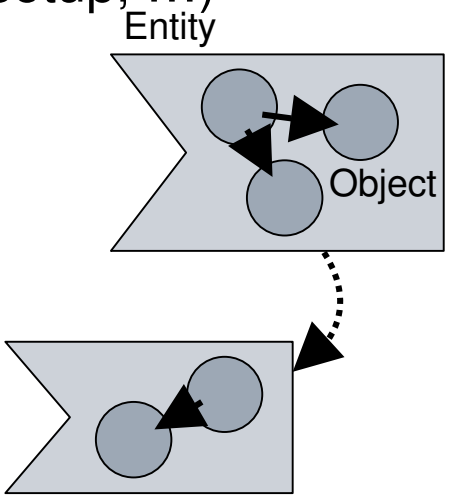
Overview


JiST
Java in Simulation Time
- Discrete event simulation engine in Java
DUCKS
- Framework for automated simulation execution and evaluation
setup, control, evaluate
use
SWANS
Scalable Wireless Ad Hoc Network Simulator
- Library for MANET simulations
VANS extensions
- Geographic routing
UULM
STRAW
- Street Mobility Model
Cornell University
North Western University

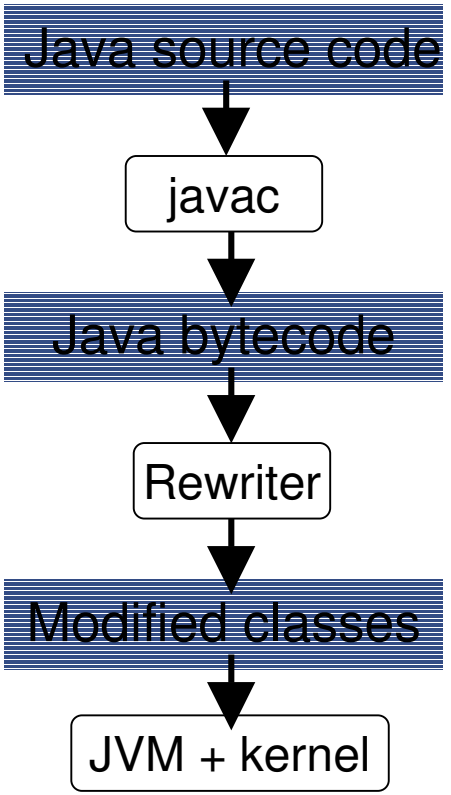
JiST – Simulation Kernel

- Basic idea: Convert virtual machine into simulation platform
  - Introduce virtual time
  - Make use of modern language concepts
- Base: Java and JVM
  - All components are pure Java
    (Rewriter, simulation kernel, library, simulation setup, …)
  - Reuse Java: reflection, interfaces, libraries, …
- Kernel
  - Strict partitioning of a simulation into entities
  - Method invocations on objects marked as entities represent simulation events
  - No explicit event queue, but virtual, explicit time progress



JiST – System architecture

- Java source files are compiled with regular Java compiler
- Running JiST invokes Rewriter
  - Rewriter modifies Java bytecode to introduce simulation time semantics
- JiST invokes simulation program
  - Rewritten program interacts with simu kernel
  - Virtual time progress independent of program progress (instructions take zero virtual time)
  - Time is advanced explicitly via `JistAPI.sleep()`
  - Time synchronization between Entities on method invocation (each Entity runs at own simulation time)
- Classes may be used without underlying JiST Kernel



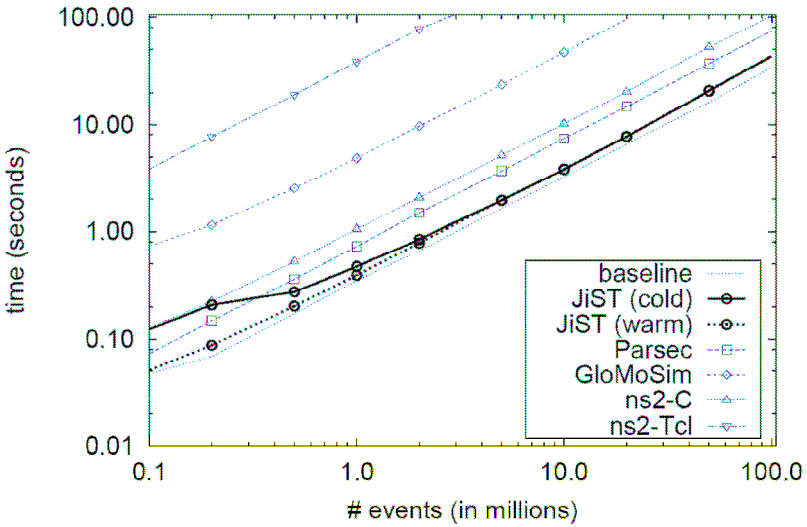
JiST example

```
import jist.runtime.JistAPI;

class Hello implements JistAPI.Entity {

   public static void main(String[] args) {
      System.out.println("Simulation start");
      Hello h = new Hello();
      h.doSequence(3);
   }

   public void doSequence(int count) {
      while( count > 0 ) {
         JistAPI.sleep(1);
         System.out.println("Hello t="+JistAPI.getTime());
         count--;
      }
   }
}
```

```
# java jist.runtime.Main Hello
> Simulation start
> Hello t=1
> Hello t=2
> Hello t=3
```

JiST – Performance

- Event troughput
  - ~ three times faster than ns2-C
  - ns2-Tcl shows extreme performance degradation
  - JiST shows kink in the first simulation second due to JIT compiler



5×10^6 events	time (sec)	vs. baseline	vs. JiST
baseline	1.640	1.0x	0.8x
JiST	**1.957**	**1.2x**	**1.0x**
Parsec	3.705	2.3x	1.9x
ns2-C	5.151	3.1x	2.6x
GloMoSim	23.720	14.5x	12.1x
ns2-Tcl	160.514	97.9x	82.0x

- Memory footprint

memory	entity	event	10K nodes sim.
JiST	**36 B**	**36 B**	**21 MB**
GloMoSim	36 B	64 B	35 MB
ns2	544 B	36 B*	72 MB*
Parsec	28536 B	64 B	2885 MB

Source: JiST User Guide

SWANS

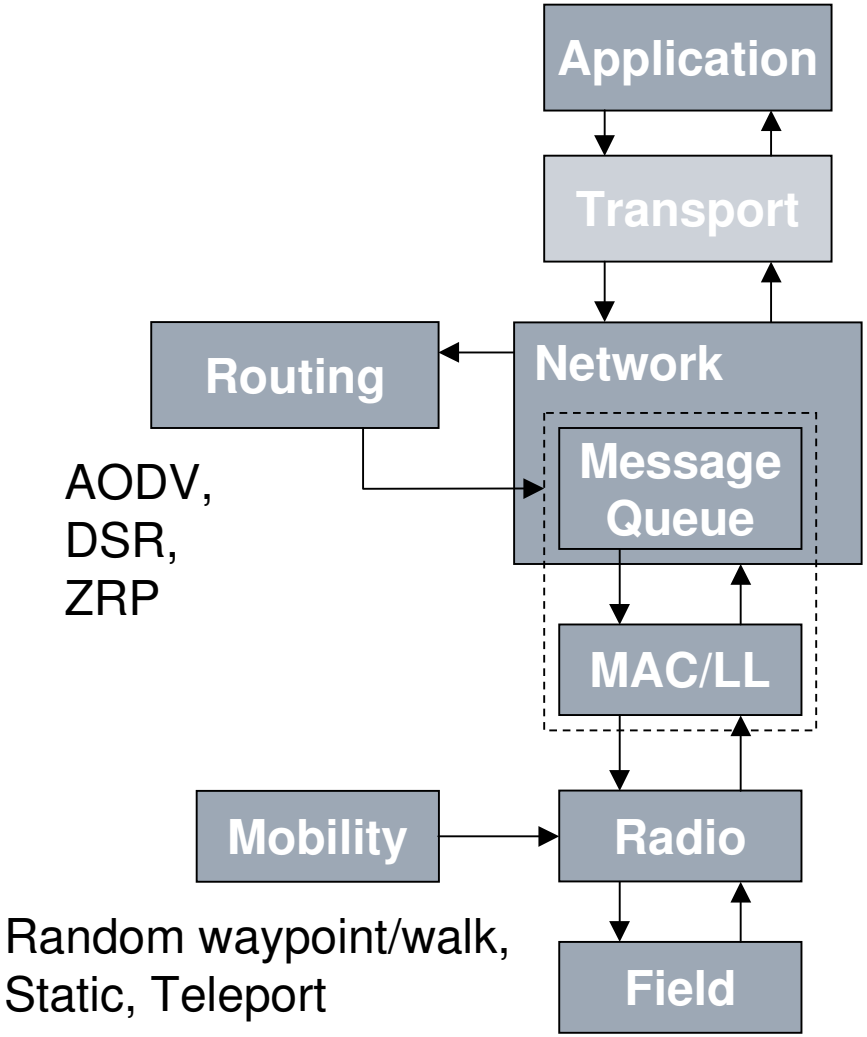
- Library for MANET simulations
- SWANS is an application of JiST
- Special properties:
  - Promises to handle huge node numbers with reasonable time/memory requirements
    Example: Neighbor Discovery Protocol, 15 minutes

t=15m	ns2		GloMoSim		SWANS		SWANS-hier	
nodes	time	memory	time	memory	time	memory	time	memory
500	7136.3 s	58761 KB	81.6 s	5759 KB	53.5 s	700 KB	*43.1 s*	1101 KB
5000			6191.4 s	27570 KB	3249.6 s	4887 KB	*433.0 s*	5284 KB
50000						47717 KB	*4377.0 s*	49262 KB

Source: http://jist.ece.cornell.edu/docs/031112-ece2.pdf

  - Efficient signal propagation by hierarchical binning
  - Allows running standard Java network apps over simulated networks

SWANS overview



CBR, heartbeat, legacy Java networking

UDP, TCP

IPv4

IEEE 802.11b, Naive MAC

Indep. & additive noise

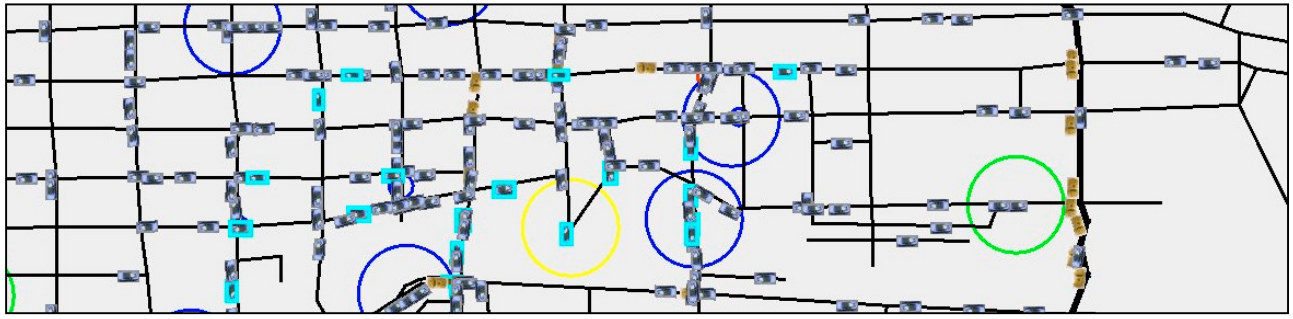
Zero, Rayleigh or Rician fading, Free-space or Two-Ray path-loss

VANET simulations

- Node mobility model — STRAW
  - Vehicle movements
    - High velocities
    - Quasi one-dimensional movements on highways
    - Short encounters of oncoming traffic
  - Vehicle Behavior
- Radio/Medium Access
  - Decentralized medium access, bandwidth allocation
  - Realistic radio propagation in urban environments
- Routing — Currently implemented by UULM
  - Position-based routing particularly suitable
- Applications
  - Extreme variety of application ideas
  - Other C2C projects?

STRAW Mobility Model

- By Northwestern University, Aqualab
  - http://www.aqualab.cs.northwestern.edu/projects/STRAW/index.php
- Written for JiST/SWANS
- Models vehicular node movements on streets
  - Structures: segments, ramps, intersections
  - Movements: acceleration, deceleration, …
- Uses TIGER® street maps
  - By U.S. Census Bureau



DUCKS simulation framework

- Problem:
  - JiST/SWANS lacks tools for handling simulation parameters and output
- Solutions by DUCKS:
  - Easily define complete simulation scenarios by config files (e.g. various simulation setup parameters like field size, node number, ...)
  - Automated execution of simulations
  - Easy distribution of simulation on multiple servers
  - Structured statistics collection, storage and evaluation
- Implementation nearly finished
  (still fixing some issues and extending usability)

DUCKS architecture

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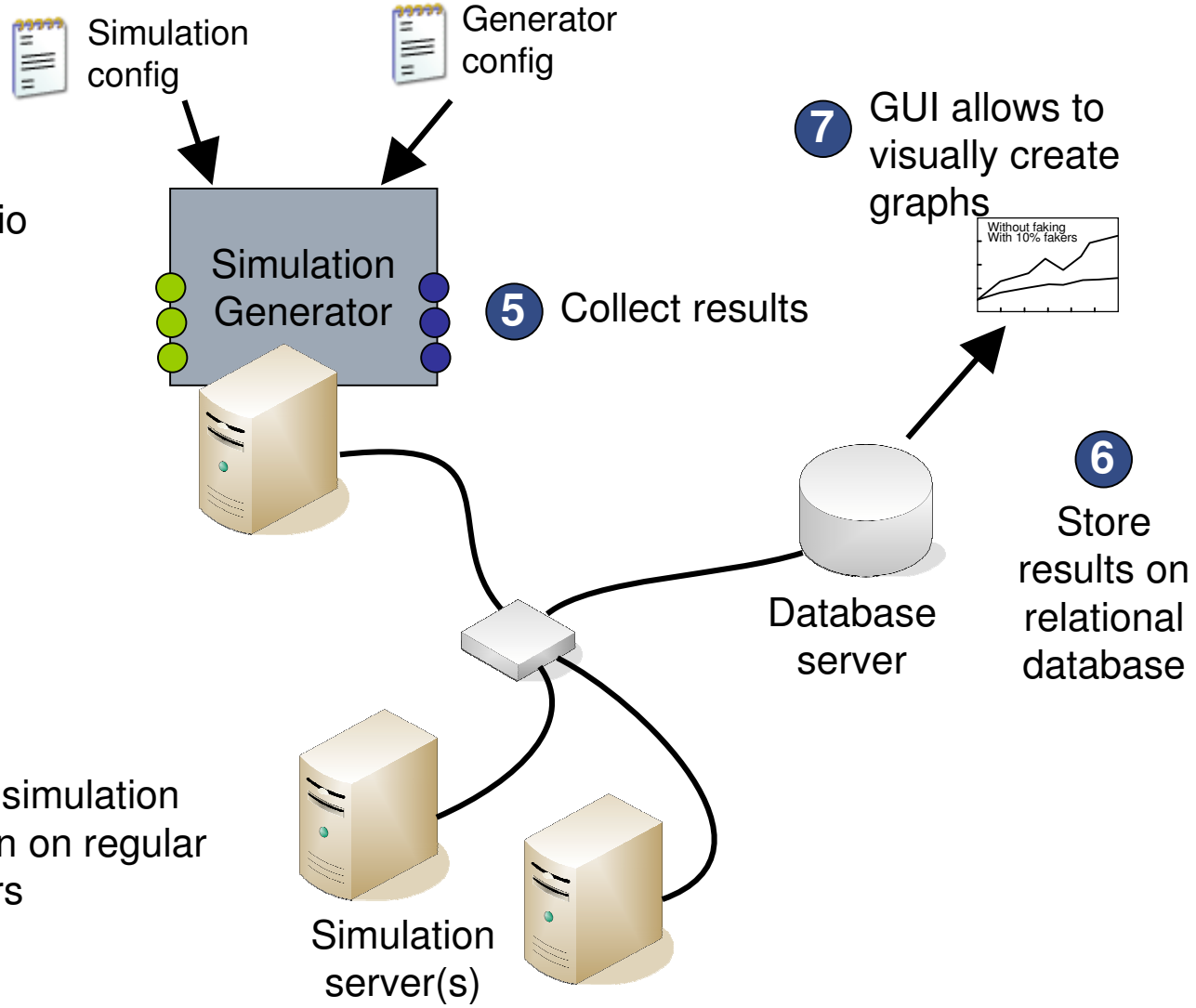
1. Defines complete simulation scenario
2. Demultiplexes scenario to single simulations
3. Distributes jobs to simulation servers
4. Distributed simulation computation on regular JiST-servers
5. Collect results
6. Store results on relational database
7. GUI allows to visually create graphs



DUCKS config file example

```
ducks.config.runs=20

ducks.general.fieldsize.x=500,1000
ducks.general.fieldsize.y=(ducks.general.fieldsize.x <-> 500,1000)
ducks.general.nodes=50-200/50,500

ducks.general.duration=120
ducks.general.waittime.start=10
ducks.general.waittime.end=(-> ducks.general.waittime.start)

ducks.mobility.movement=waypoint
ducks.mobility.waypoint.speed.min=1
ducks.mobility.waypoint.speed.max=5,20
ducks.mobility.waypoint.pausetime=(ducks.mobility.waypoint.speed.max == 5 ? 0 : 10)
ducks.mobility.waypoint.precision=100

ducks.traffic.type=cbr
ducks.traffic.cbr.rate=20
ducks.traffic.cbr.packetspercon=1
ducks.traffic.cbr.waittime=0

ducks.routing.protocol=aodv

ducks.mac.protocol=802.11
```

JiST/SWANS Pros & Cons

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Pros

- Fast & scalable
- Completely Java-based approach
  - Advantages of Java (Garbage collection, type-safety, reflection, library, …)
  - No other language needed
  - Portability of JVM
- Interesting virtual time concept
- Usage of legacy, socket-based Java applications is possible

Cons

- Maturity unproven
  - Still little attention in research community
  - Correctness of implementation
  - Minor bugs/deficiencies
  - Issues regarding platform independence
- Sparse tool support
  - No GUI modeling/output
  - No framework for automated simulation execution
    - leveraged by DUCKS

Further work

- Ongoing activities
  - Implementation of geographic routing
  - Implementation of positioning and position verification
  - DUCKS consolidation
  - Performance tests
- Planned activities
  - More realistic signal propagation models
    e.g. including obstacles like buildings
  - Abstraction layer to be able to switch between
    simulator and real hardware
- Scientific plans
  - Qualitative comparison of SWANS and ns-2
    (e.g. regarding delivery ratio, delay, …)
  - Use for SEVECOM protocol validation