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Enhancing the Credibility of Wireless Network Simulations with Experiment Automation

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Why we run simulations

We need to understand the technology before we can rely on it for mission-critical applications.

Performance can be **quantified**/**estimated** with computer simulation.

Credibility issues

Experiments published are not always **reproducible**.

- What was the version of the simulator used?
- What what sub-models were used?
- Where to find the complete experimental set up?

Credibility issues

Output data is **unavailable** or **unreliable**.

- Papers publish a thin "*slice*" of experimental results.
- Methodology to compute the statistics of output data doesn't conform to best practices.
- Plots without units on axes, legends on data series, and/or confidence intervals.

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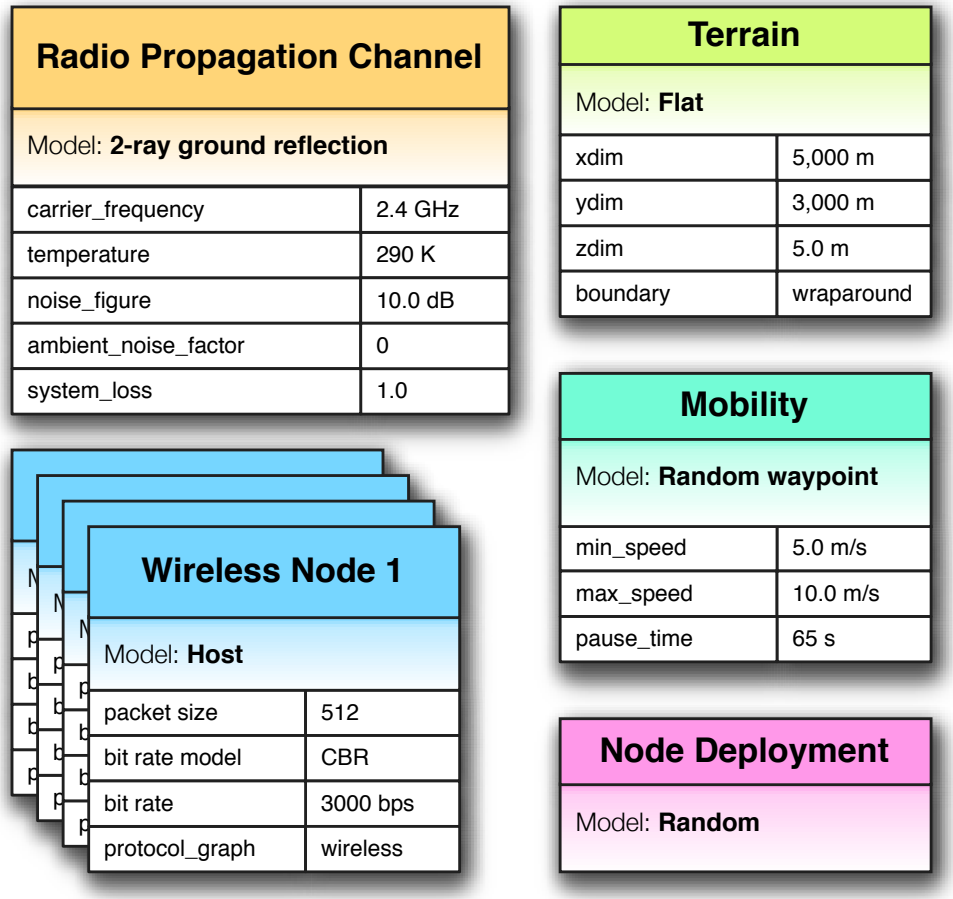
Credibility issues

We know **where** and **how** we're failing.

- T. Camp, S. Kurkowski, and M. Colagrosso, "MANET simulation studies: The Incredibles," SIGMOBILE Mob. Comput. Commun. Rev., vol. 9, no. 4, pp. 50–61, 2005.
- K. Pawlikowski, H. J. Jeong, and J. R. Lee, "On credibility of simulation studies of telecommunication networks," IEEE Communications Magazine, vol. 40, January 2002.
- C. Cicconetti, E. Mingozzi, and G. Stea, "An integrated framework for enabling effective data collection and statistical analysis with ns-2," in Proceedings from the 2006 Workshop on ns-2, Pisa, Italy, October 2006.
- ...

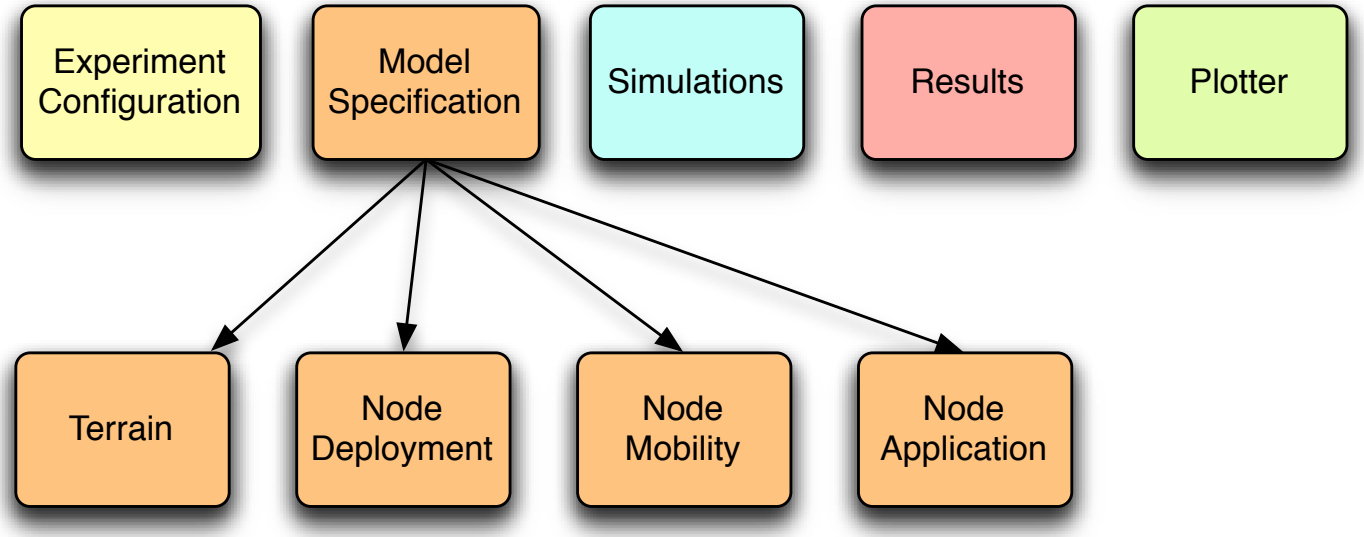
We can use automation solutions to avoid problems.

Model Composition



SWAN Tools

A web-based application that guides the construction of the simulation experimental study and its data analysis. SWAN Tools is self-documenting: it allows experiments to be reproducible.



Web-based Interface to SWAN

- Control of the simulation process:
  - Experiment design
  - Configuration
  - Execution
  - Data analysis
- Remote access via a web browser.
- Browser talks to server which automates the simulation process.

Experiment Configuration

- User can work with multiple experiments.
- Each experiment is bound to a specific code base of the simulator (user uploaded).
- For each experiment, define number of runs for each simulation, random number generator seeds, length of transient time (for data deletion).
- User can't change an ongoing or completed experiment.

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Model Specification

- GUIs guide the user to enter all the parameters for all the sub-models employed.
- No default values for model parameters.
- Validates parameter data.
- Shows the units for each parameter and helps user to understand context.
- Experiment design builds list of levels for each parameter.

Simulations

- Generates all design points for the experiment.
- Creates a configuration file for each simulation run.
- Dispatches simulation runs for an experiment across multiple processors (multiple replications in parallel - MRIP).

Results

- User can see the *raw data* from each simulation run.
- Results are stored together with the configuration that was used to generate them.
- Uses established methodology to generate statistics (average, standard deviation, confidence intervals, etc.)

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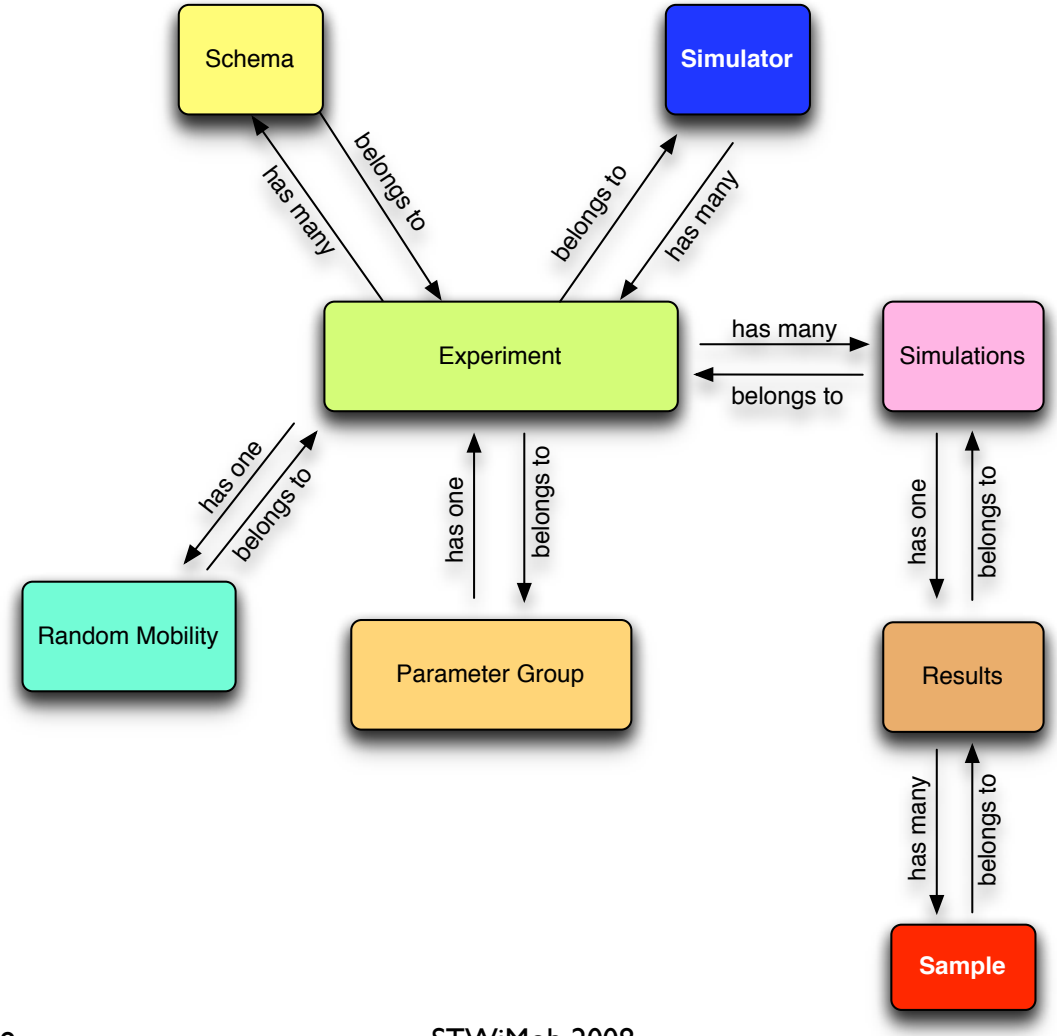
Plotter

- User can request the system to built plots from stored results.
- The user can define what the plot will include from the web browser. The system processes the relevant data, generates *a plot that meets standards*, and sends the results back to the browser for display or download.

Implementation
or
Why Ruby on Rails Rocks

It's All about the Database



Database Interactions

- Migrations
  - Easy to add/remove columns or tables
  - Agile for developers
- Abstraction
  - Data accessible as class variables
  - Easily map relations between classes

Ruby

- Easy and powerful
- Metaprogramming
  - Dynamically create new methods
  - Flexibility

AJAX

- AJAX helpers provided by Ruby on Rails
- Easier interface
  - Reduced page loads and refreshes
- Component validation
  - Constrains user to enter only valid parameters

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Embedded Ruby (ERb)

- Views
  - Dynamic content with embedded ruby in views
  - Access to RoR AJAX helper functions
- DML Configuration
  - Dynamically generate configuration files
  - Allows for a single global template

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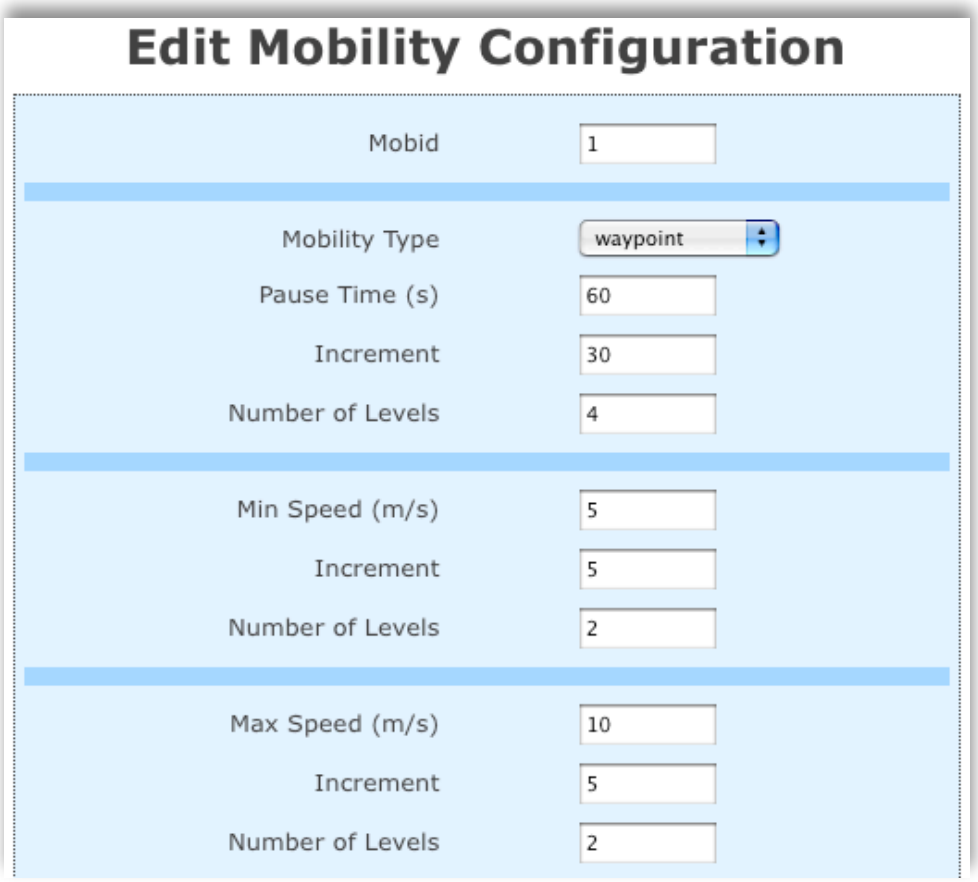
DML Configuration file

```
mobility [
      model "mobility.random" # import models for random movement
      deployment "random" # distribute mobiles uniformly in space
      period 1 # time interval between position updates in sec.

 motion [
         type "waypoint"  # use random waypoint mobility.
         mobid 1            # unique identifier for this pattern of movement
         pause_time 4    #  pause time
         min_speed 5     # minimum node speed
         max_speed 30  # maximum node speed
      ] # end of random waypoint motion

  ...
]
```

Is this configuration interface safer?



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DML Configuration file

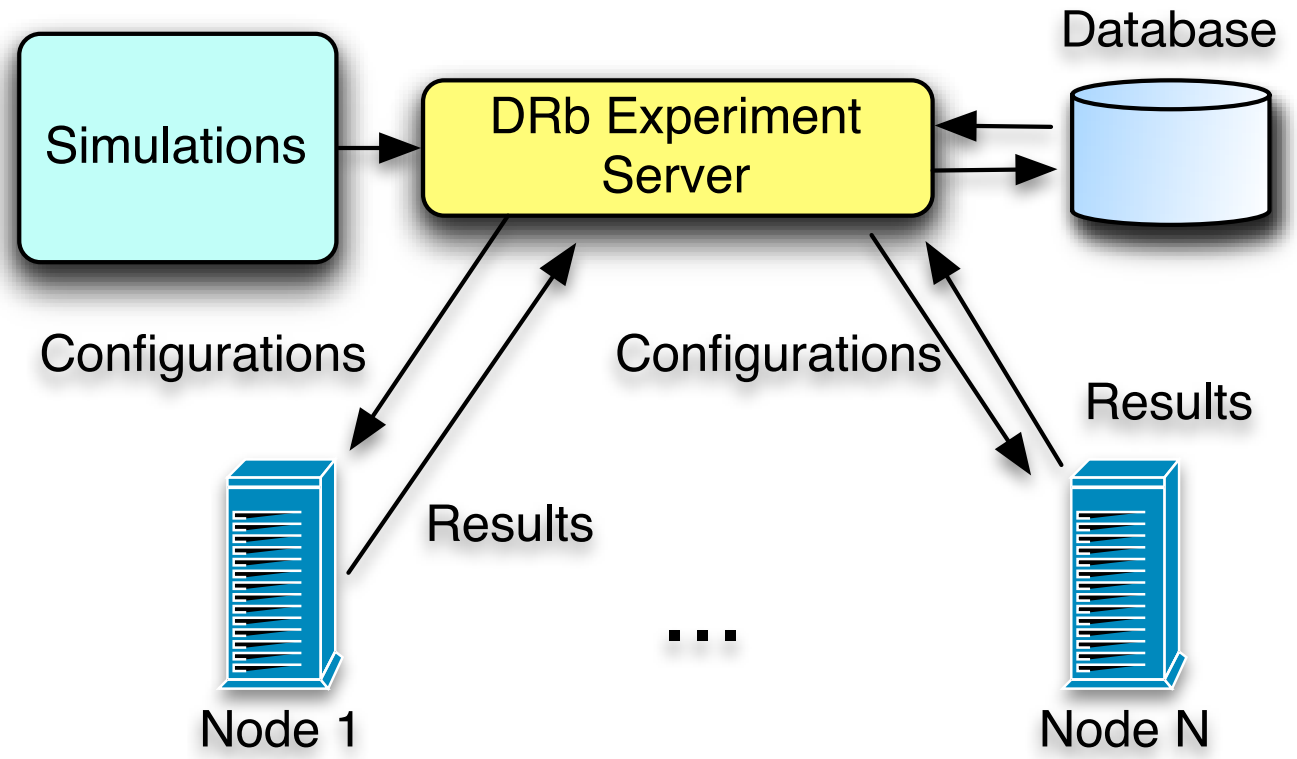
```
mobility [
    model <%= self.model %> # import models for random movement
    deployment <%= self.deployment %> # distribute mobiles uniformly in space
    period <%= self.period %> # time interval between position updates in sec.

 motion [
      type <%= self.motion_type %>  # use random waypoint mobility.
      mobid <%= self.mob_id %> # unique identifier for this pattern of movement

      pause_time <%= self.pause_time %>    #  pause time
      min_speed <%= self.min_speed %>     # minimum node speed
      max_speed <%= self.max_speed %>  # maximum node speed
    ] # end of random waypoint motion

  ...
] #end of mobility
```

Distributed Ruby (DRb)

Multiple Replications in Parallel (MRIP)

- Run on multiple systems
- Collect more samples by running more simulations
- All results reported to server process
- Statistics automatically generated – no user error
- Results stored on filesystem and in database

DRb and MRIP


Database
Simulations
DRb Experiment Server
Configurations
Configurations
Results
Results
...
Node 1
Node N

Future Work

- AJAX plotting utility.
- AJAX runtime queue management.
- Automatically determine length of transient and length of simulation run given a desired level of confidence.