



# How to Implement and Evaluate Mobility Pattern in OPNET

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# Agenda

- OPNET Modeler
- Mobility in OPNET
- Mobility Pattern Evaluation
- Mobility Pattern Implementation
- Conclusion



Agenda

OPNET Modeler

Mobility Pattern

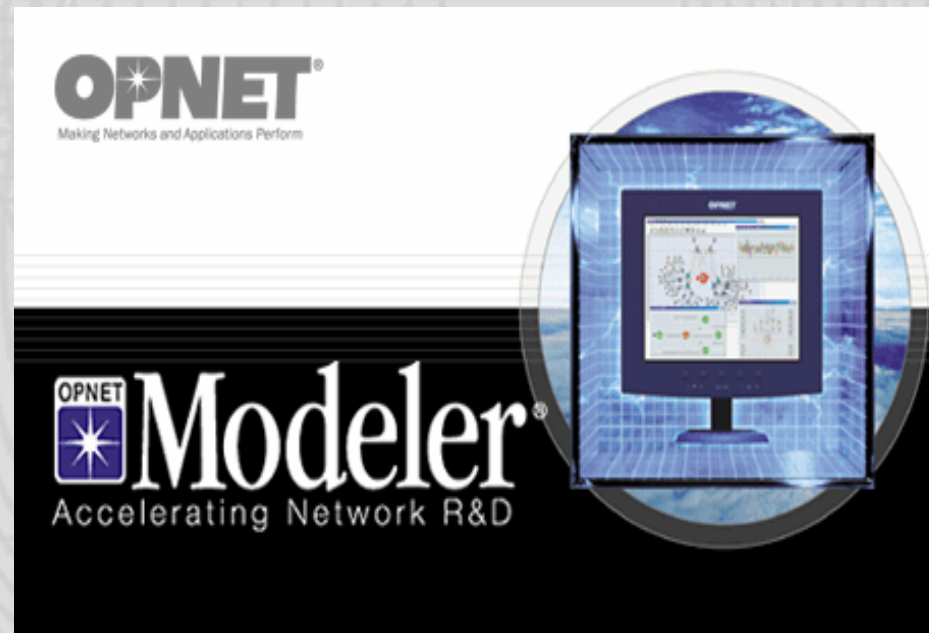
Evaluation

Implementation

Conclusion

# OPNET Modeler

- Network Simulator
- Event-Based
- Commercial



Agenda

OPNET Modeler

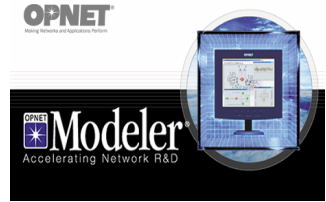
Mobility Pattern

Evaluation

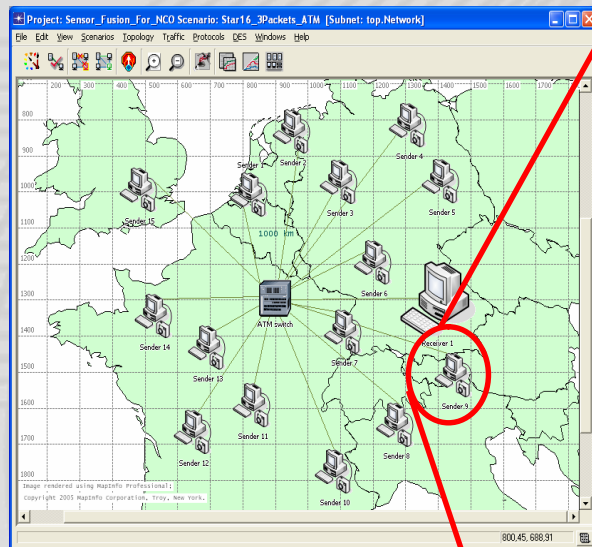
Implementation

Conclusion

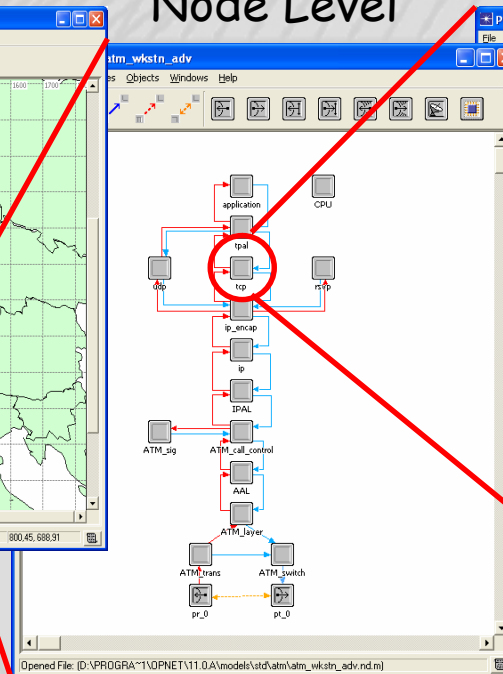
# OPNET Modeler



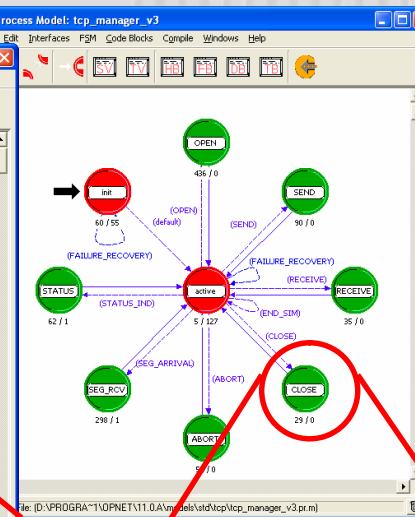
Network Level



Node Level



Process Level



C-Level

```

tcp_manager_v3 : CLOSE : Enter Execs
1  if (op_tci_attr_get (tci_ptr, "conn_id", &conn_id) == OPC_COMPCODE_F
2  op_prg_log_entry_write (l1_loghdl,
3  "TCP CLOSE failed - unable to get connection ID from com
4
5  if (op_tci_attr_get (tci_ptr, "local_key", &local_key) == OPC_COMPCO
6  op_prg_log_entry_write (l1_loghdl, "TCP CLOSE failed - unable t
7
8  /* Find a matching TCP socket process. */
9  tcb_ptr = tcp_tcb_from_id (tcp_dt_handle, conn_id, local_key);
10 if (tcb_ptr != OPC_NIL)
11 {
12     ev_ptr->event = TCP_EV_CLOSE;
13     if (op_pro_invoke (tcb_ptr->conn_pro, ev_ptr) == OPC_COMPCODE_FA
14     op_prg_log_entry_write (l1_loghdl,
15     "TCP CLOSE failed - unable to invoke TCP socket proc
16 }
17 else
18 {
19     if (tcp_trace_active)
20     {
21         sprintf (msg0, "CLOSE command issued to invalid connection C
22         op_prg_odt_print_major (msg0, OPC_NIL);

```

- Topology
- Links
- Nodes
- Trajectories
- Traffic Profiles

Interaction of protocol layers

Agenda

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# OPNET Modeler

## Strengths:

- Large library
- GUI
- Debug
- Support
- Modular Concept

## Weakness:

- Physical Layer
- Result gathering
- Result visualization

## Other popular network simulation tools:

- NS-2
- OMNET++



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

## Mobility - OPNET

- **Mobility Types:**

- Direct
- Trajectory
- Vector
- Cosimulation

- **Mobile Objects:**

- Subnet
- Node

- **Position:**

- Latitude
- Longitude
- Altitude

- **Orientation:**

- Yaw
- Pitch
- Roll



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

# Mobility - Trajectory



- List of trajectory entries
  - Position
  - Orientation
  - Simulation time
- Interpolation between two points

- Agenda
- OPNET Modeler
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**Edit Trajectory Information**

Trajectory name: ITG\_Trajectory

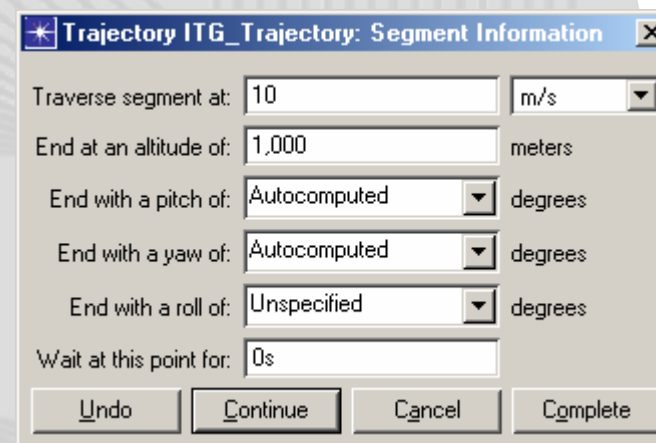
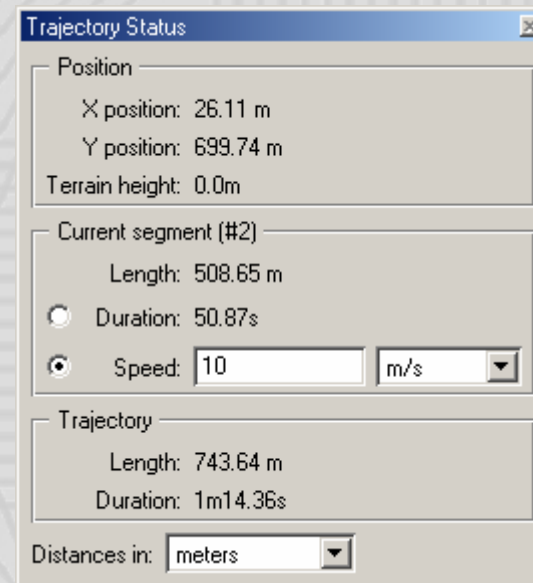
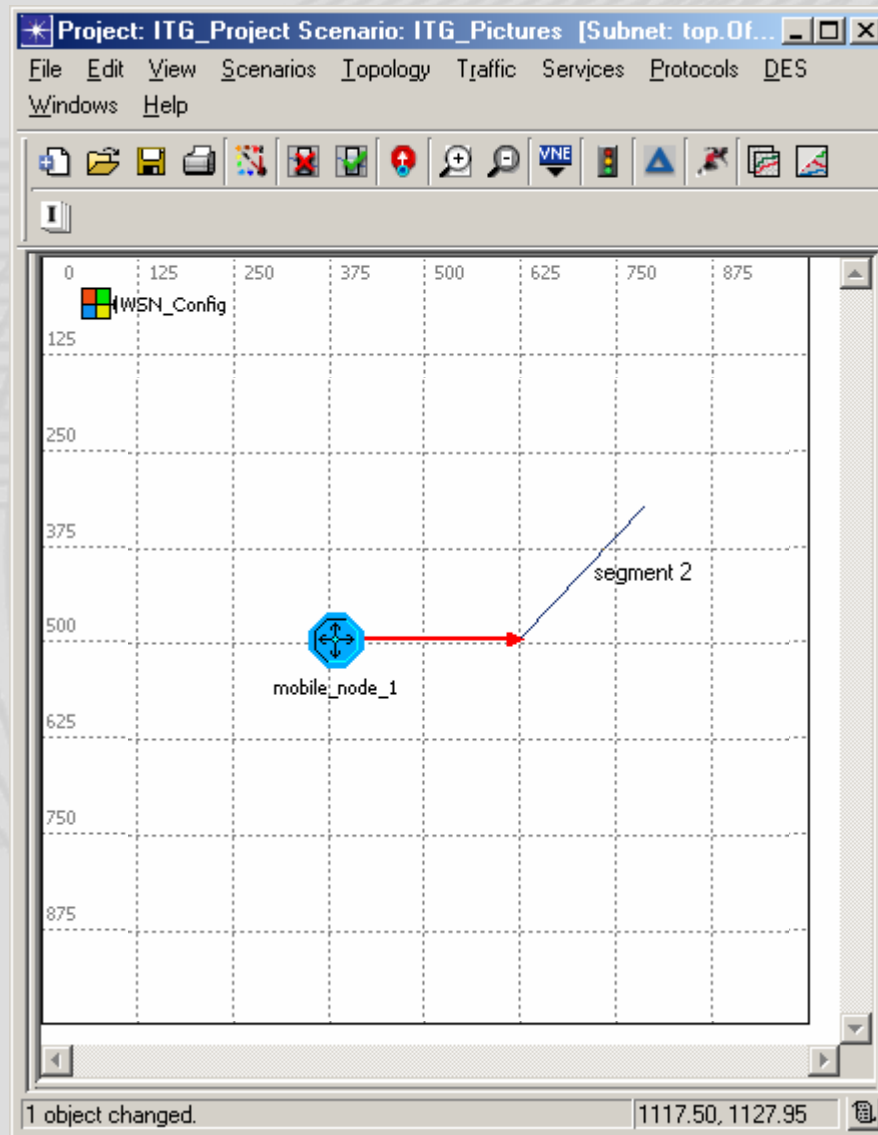
	X Pos (m)	Y Pos (m)	Distance (m)	Altitude (m)	Traverse Time	Ground Speed	Wait Time	Accum Time	Pitch (degrees)	Yaw (degrees)	Roll (degrees)
1	271.542794	866.848152	n/a	...0.000000	n/a	n/a	00.00s	00.00s	Autocomputed	Autocomputed	Unspecified
2	506.531751	866.848152	234.988989	...0.000000	23.50s	9.999531	00.00s	23.50s	Autocomputed	Autocomputed	Unspecified
3	731.076754	830.294314	227.500860	...0.000000	22.75s	10.000038	00.00s	46.25s	Autocomputed	Autocomputed	Unspecified

Coordinates are relative to object's position

Ground speed in: m/s  
Distance in: meters  
Altitude in: meters

Insert Delete Redefine... OK Cancel

# Mobility - Trajectory



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

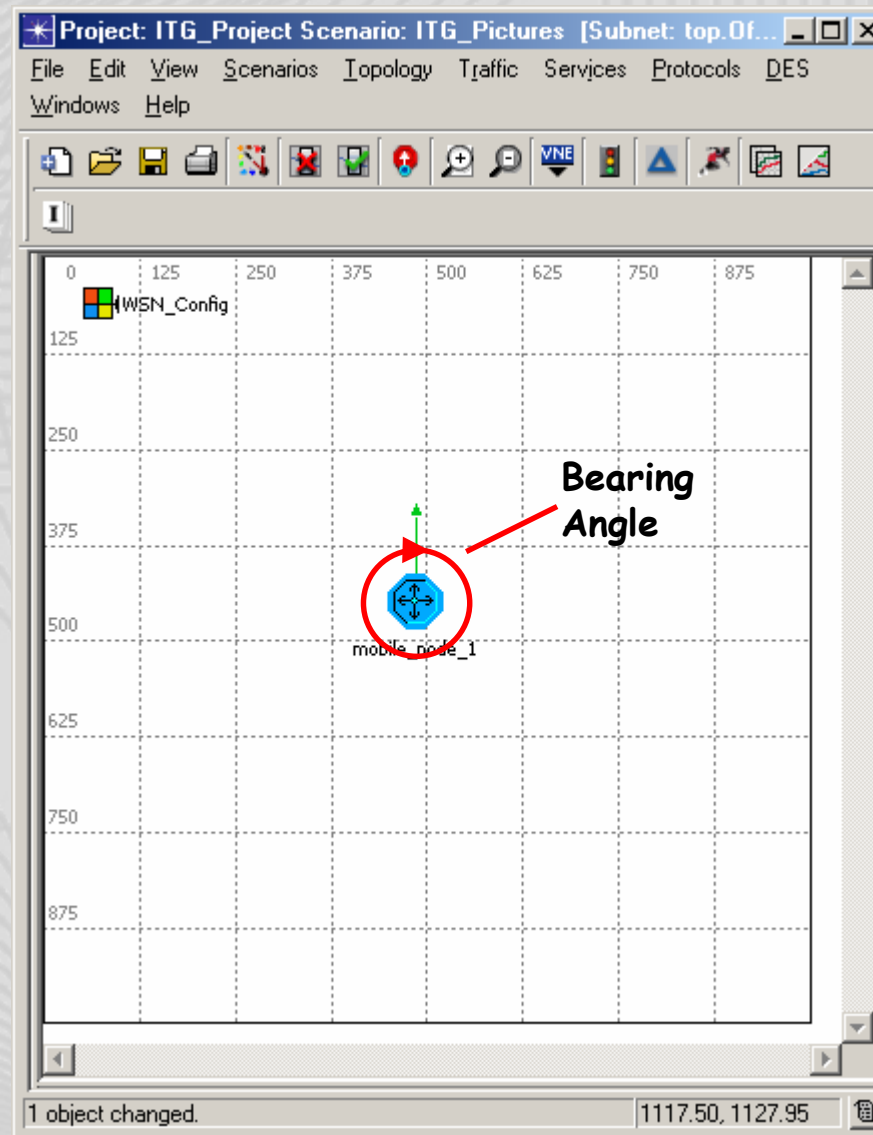
Implementation

Conclusion



## Mobility - Vector

- Bearing
- Ground speed
- Ascent rate



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

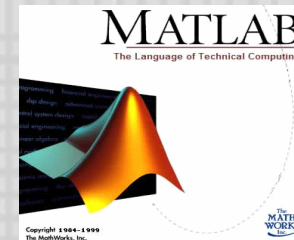
Implementation

Conclusion

# Mobility - Cosimulation



Matlab  
Engine  
Library



HLA



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

# Mobility Pattern - OPNET Library



\*(Mobility Config) Attributes

Type: Utilities

Attribute	Value
name	Mobility Config
Mobility Modeling Status	Enabled
Random Mobility Profiles	(...)
rows	3
row 0	Default Random Waypoint,Random Wa...
row 1	
Profile Name	Random Waypoint (Record Trajectory)
Mobility Model	Random Waypoint
Random Waypoint Parameters	(...)
Mobility Domain Name	Not Used
x_min (meters)	0.0
y_min (meters)	0.0
x_max (meters)	500
y_max (meters)	500
Speed (meters/seconds)	uniform_int (0, 10)
Pause Time (seconds)	constant (100)
Start Time (seconds)	constant (10)
Stop Time (seconds)	End of Simulation
Animation Update Frequency (s...	1.0
Record Trajectory	Enabled
row 2	Static,Random Waypoint,(...)

Apply changes to selected objects  Advanced

Find Next OK Cancel

Agenda

OPNET Modeler

Mobility Pattern

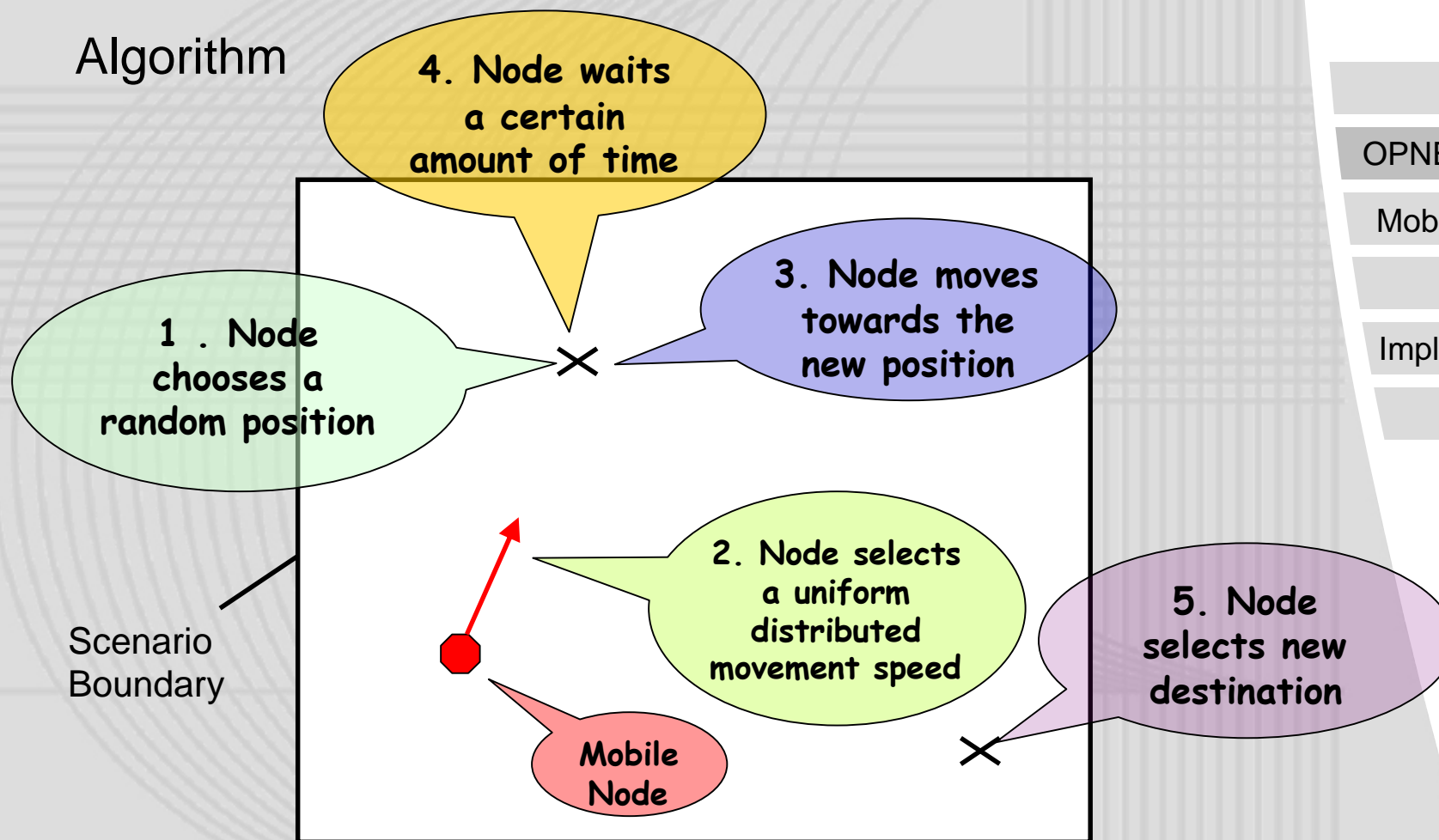
Evaluation

Implementation

Conclusion

# Mobility Pattern - Random Waypoint

## Algorithm



Agenda

OPNET Modeler

Mobility Pattern

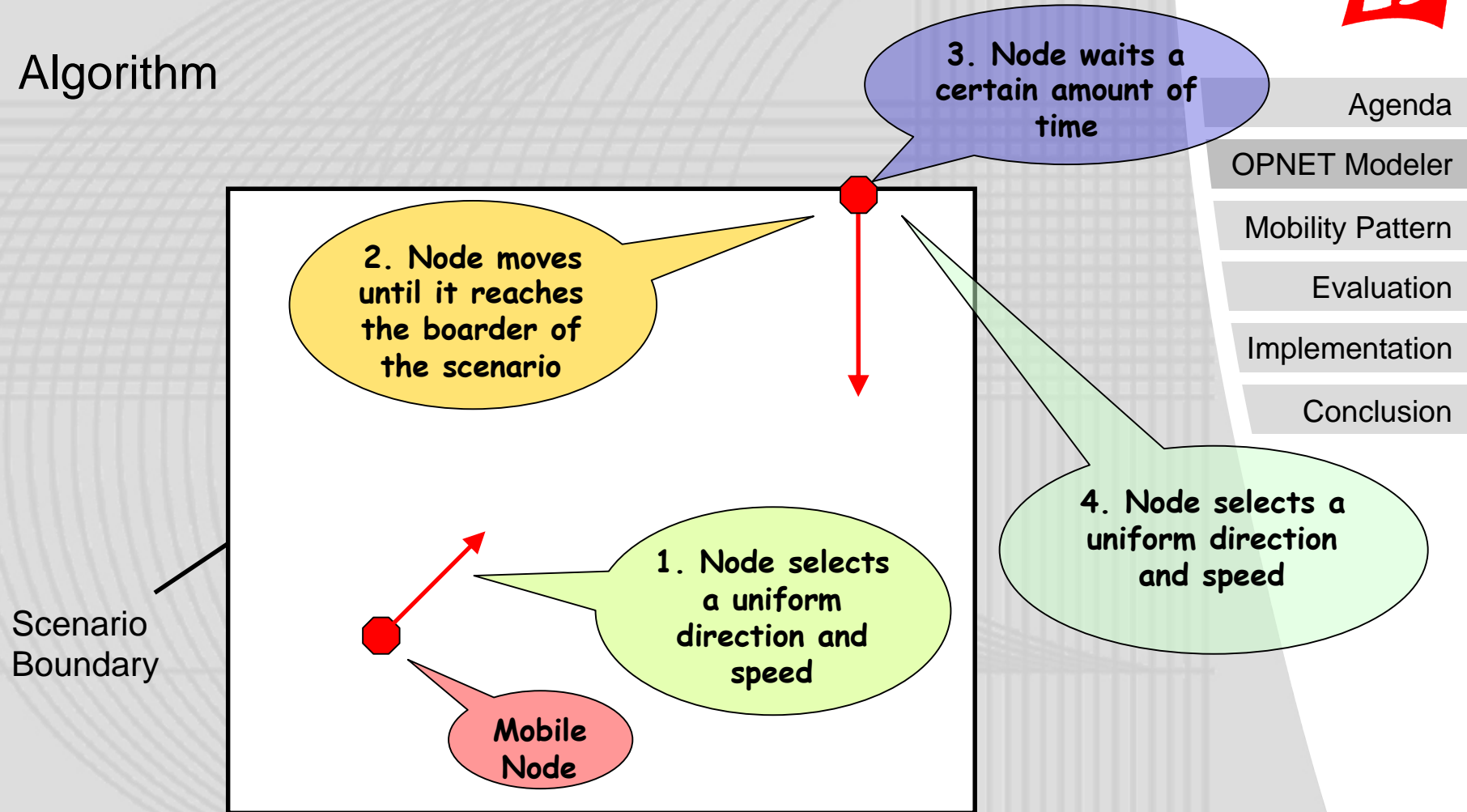
Evaluation

Implementation

Conclusion

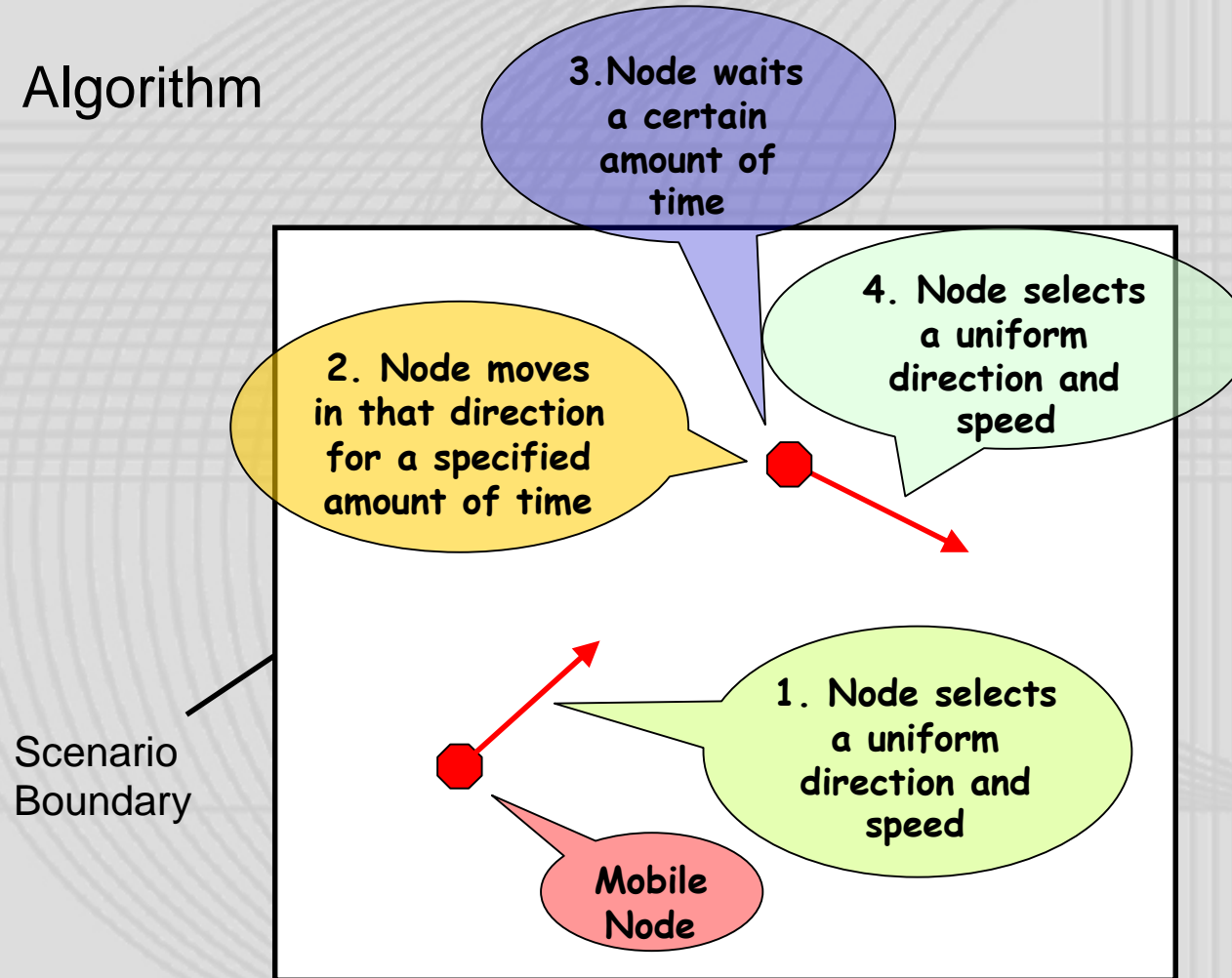
# Mobility Pattern - Random Direction

## Algorithm



# Mobility Pattern - Random Walk

## Algorithm



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

# Mobility Pattern - Evaluation

- Visualization
  - Movement (Debugging)
  - Density
  - Histograms (Speed)
- Simulation
  - Area (Square, Rectangle, Torus, ...)
  - Long-term simulation



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

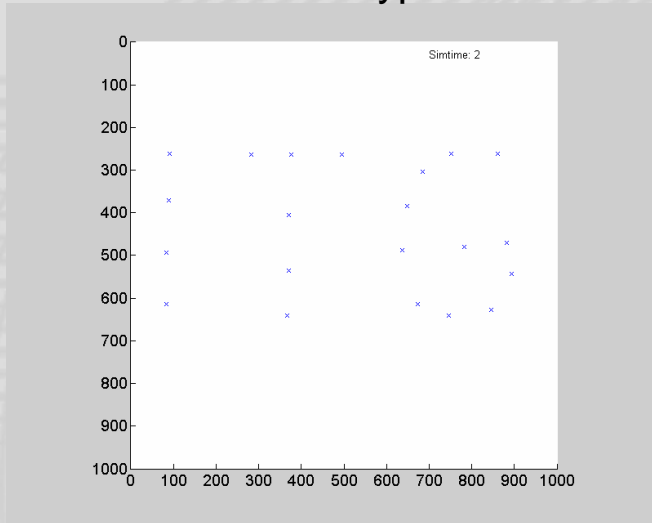
Implementation

Conclusion

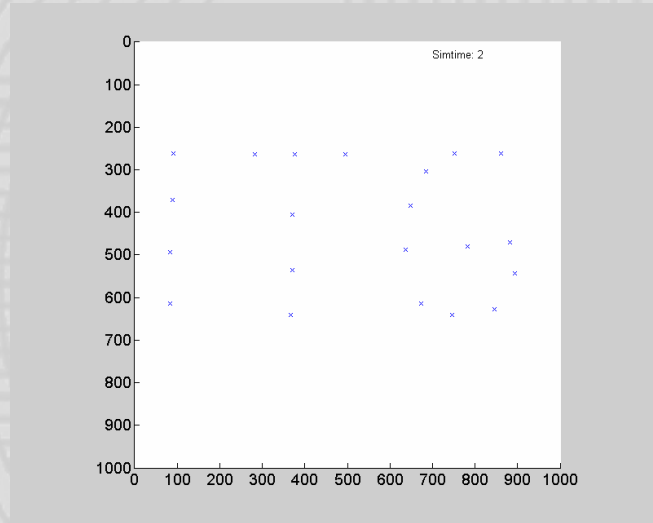
# Mobility Pattern - Evaluation



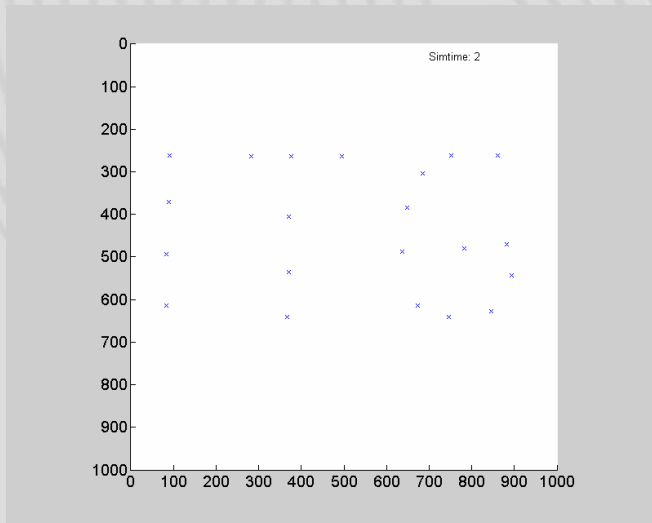
### Random Waypoint



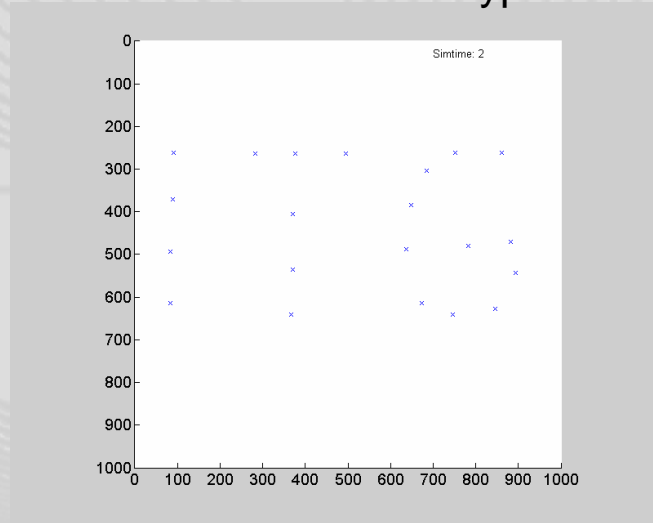
### Random Direction



### Random Walk



### OPNET – Random Waypoint



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

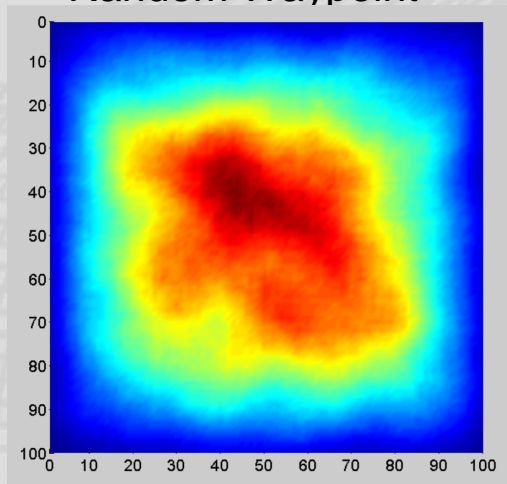
Conclusion



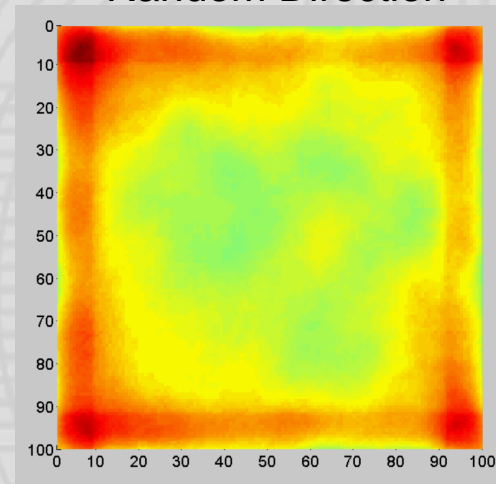
# Mobility Pattern - Evaluation - Node Density



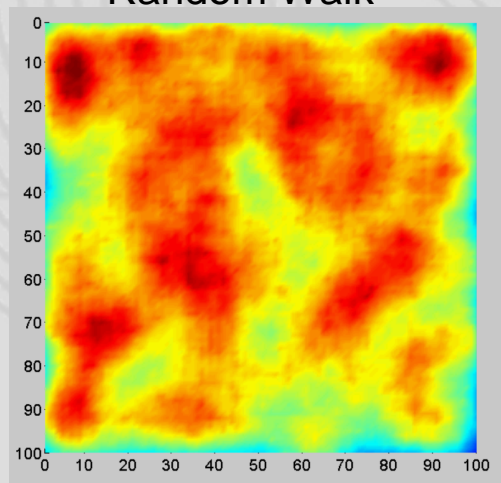
Random Waypoint



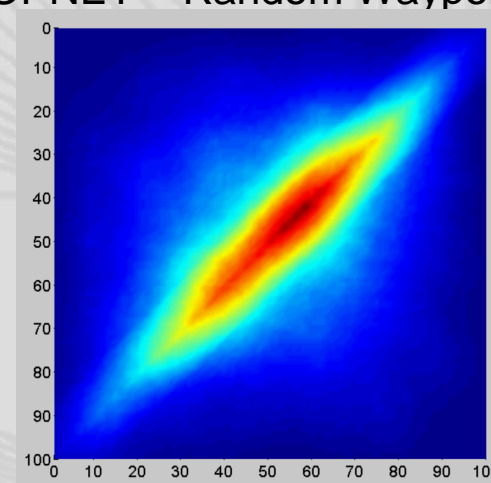
Random Direction



Random Walk



OPNET - Random Waypoint



Agenda

OPNET Modeler

Mobility Pattern

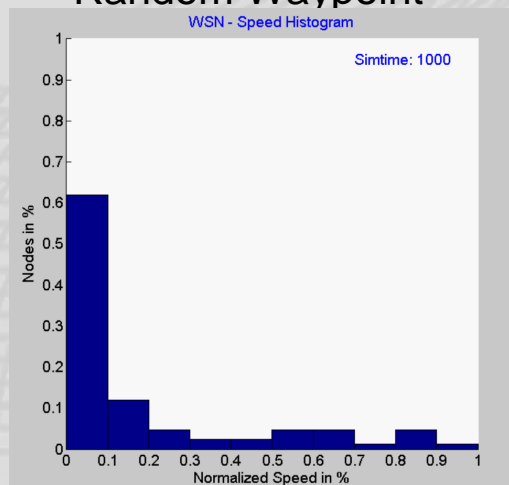
Evaluation

Implementation

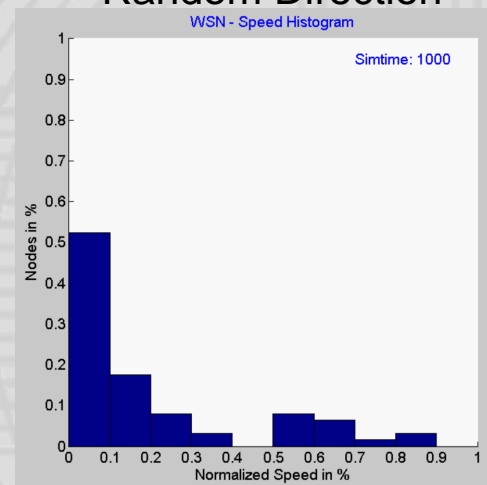
Conclusion

# Mobility Pattern - Speed Histogram

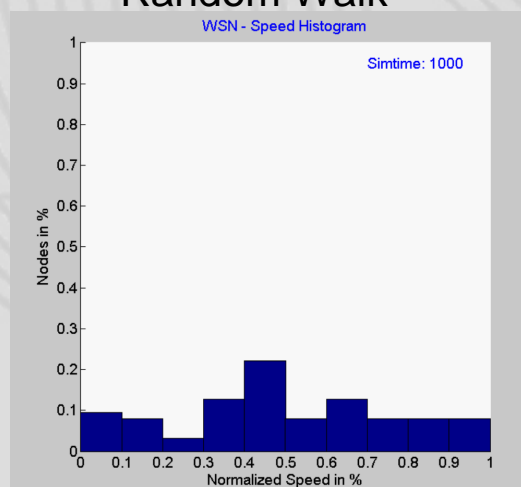
## Random Waypoint



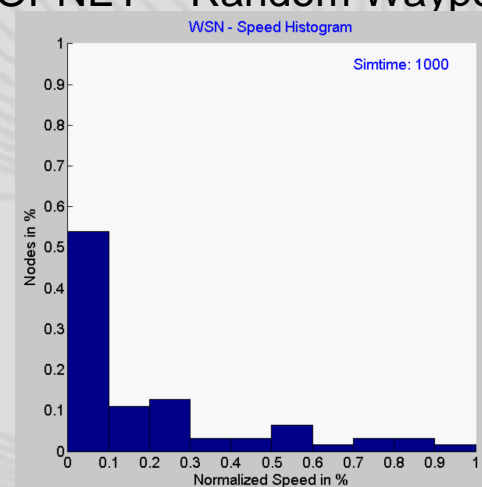
## Random Direction



## Random Walk



## OPNET – Random Waypoint



Agenda

OPNET Modeler

Mobility Pattern

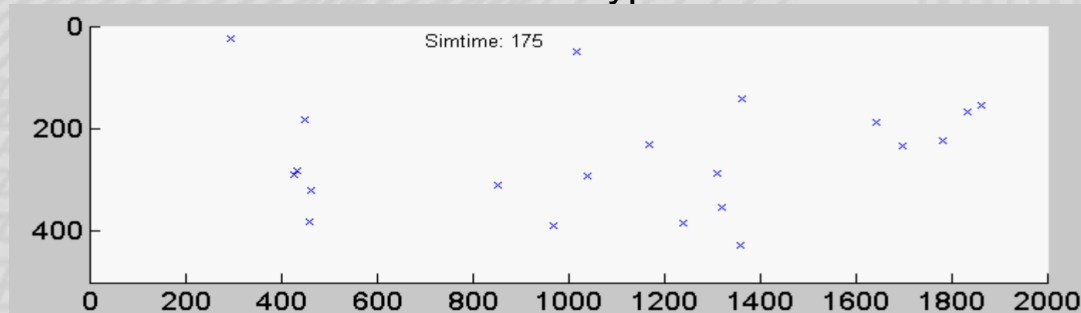
Evaluation

Implementation

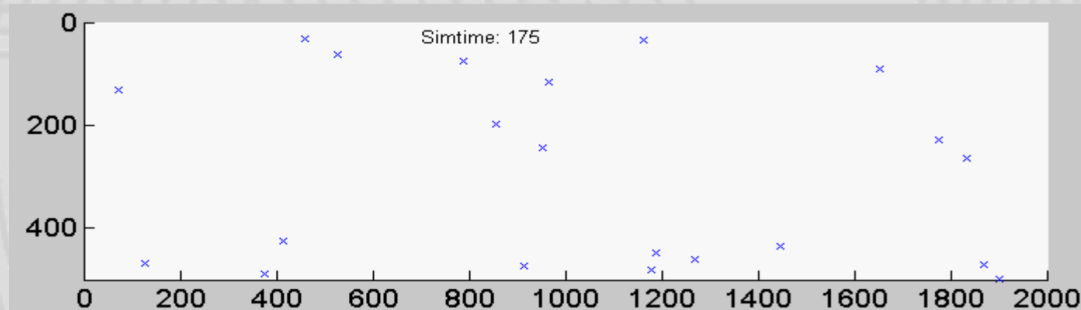
Conclusion

# Mobility Pattern - Evaluation - Area

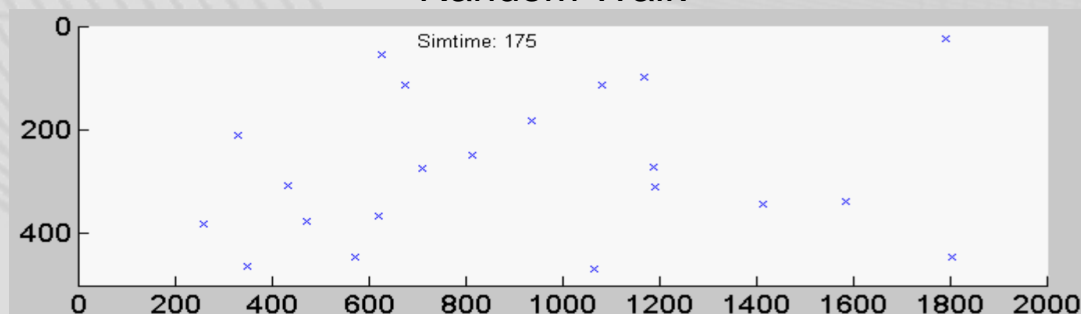
## Random Waypoint



## Random Direction



## Random Walk



Agenda

OPNET Modeler

Mobility Pattern

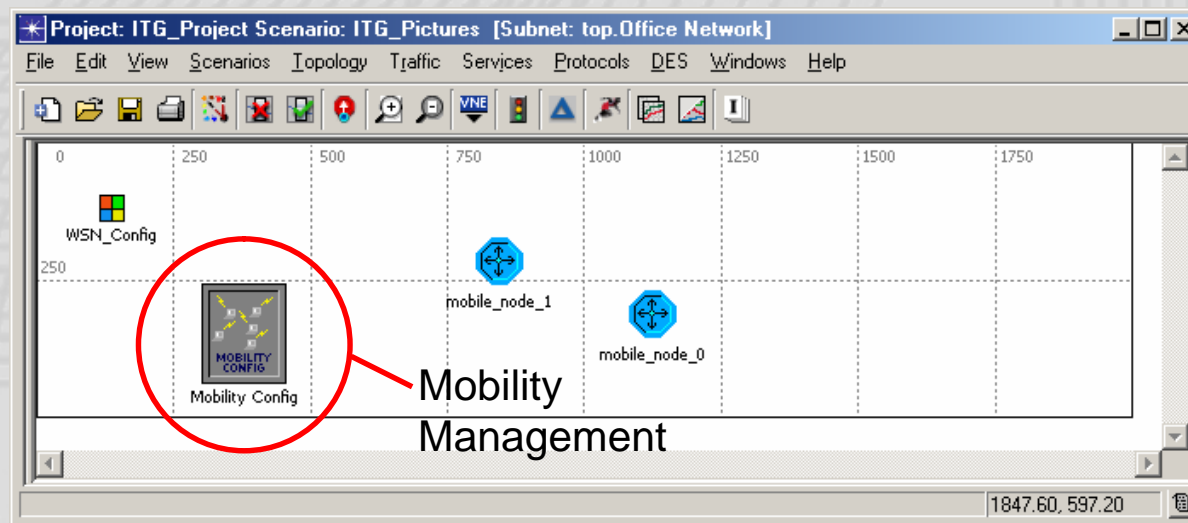
Evaluation

Implementation

Conclusion

# Mobility Pattern - Implementation

## Centralized Mobility Management



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

### Advantage:

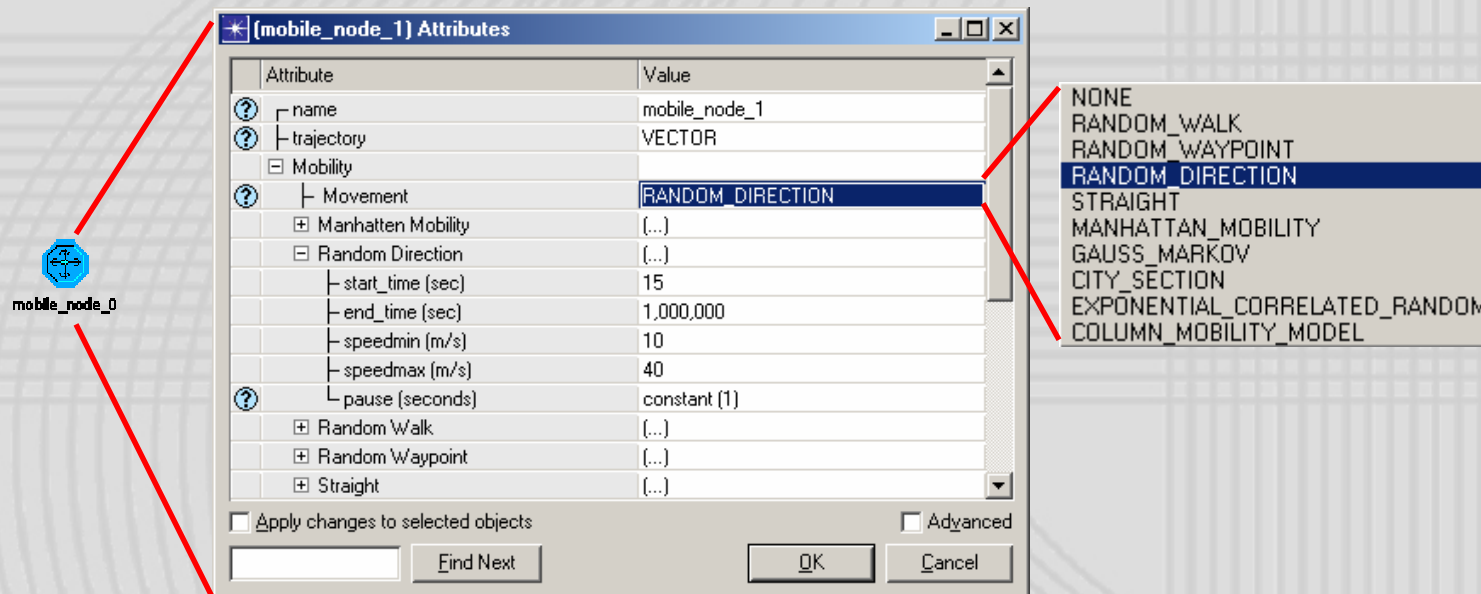
- Group mobility models
- Group statistics
- Fast reconfiguration
- No modification of other models needed

### Disadvantage:

- No individual movement
- Difficult to implement

# Mobility Pattern - Implementation

## Decentralized Mobility Management



Attribute	Value
name	mobile_node_1
trajectory	VECTOR
Mobility	
Movement	RANDOM_DIRECTION
Manhattan Mobility	(...)
Random Direction	(...)
start_time (sec)	15
end_time (sec)	1,000,000
speedmin (m/s)	10
speedmax (m/s)	40
pause (seconds)	constant (1)
Random Walk	(...)
Random Waypoint	(...)
Straight	(...)

Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

### Advantage:

- Individual configuration
- Individual statistics
- Simple to implement

### Disadvantage:

- Group statistics
- Slight modification of existing models needed (process model, attributes)

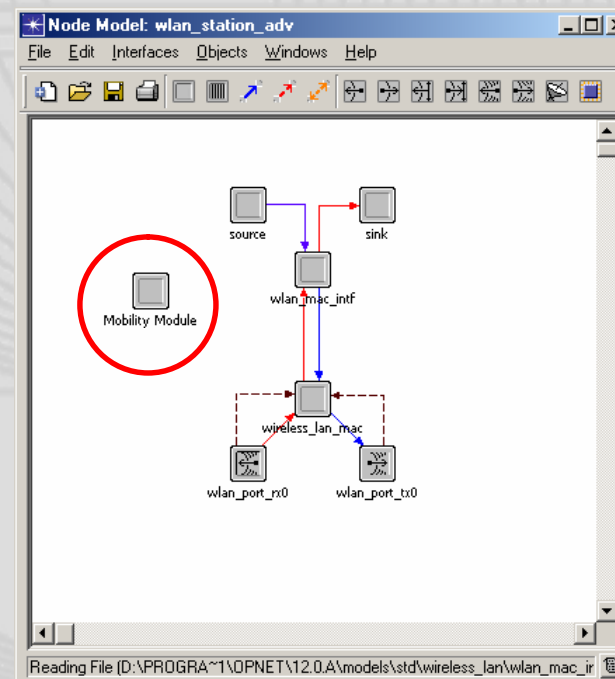
## Mobility Pattern - OPNET - Implementation

### Vector based movement:

- Frequent position updates
- Faster simulation
- Simplifies the implementation (move and stop phase)

### Implementation:

- Add a process model to the node model
- Promote its attributes
- Divide the movement into move and stop phases



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

## Conclusion

- Implement your own mobility model  
(or use at least OPNET Modeler 14.0)
- Visualize the movement to verify your model
- Consider the characteristics of the mobility model
  - Transient phase
  - Stability
  - Node density
  - Correlated movement
  - Impact of simulation area



Agenda

OPNET Modeler

Mobility Pattern

Evaluation

Implementation

Conclusion

# Questions

