

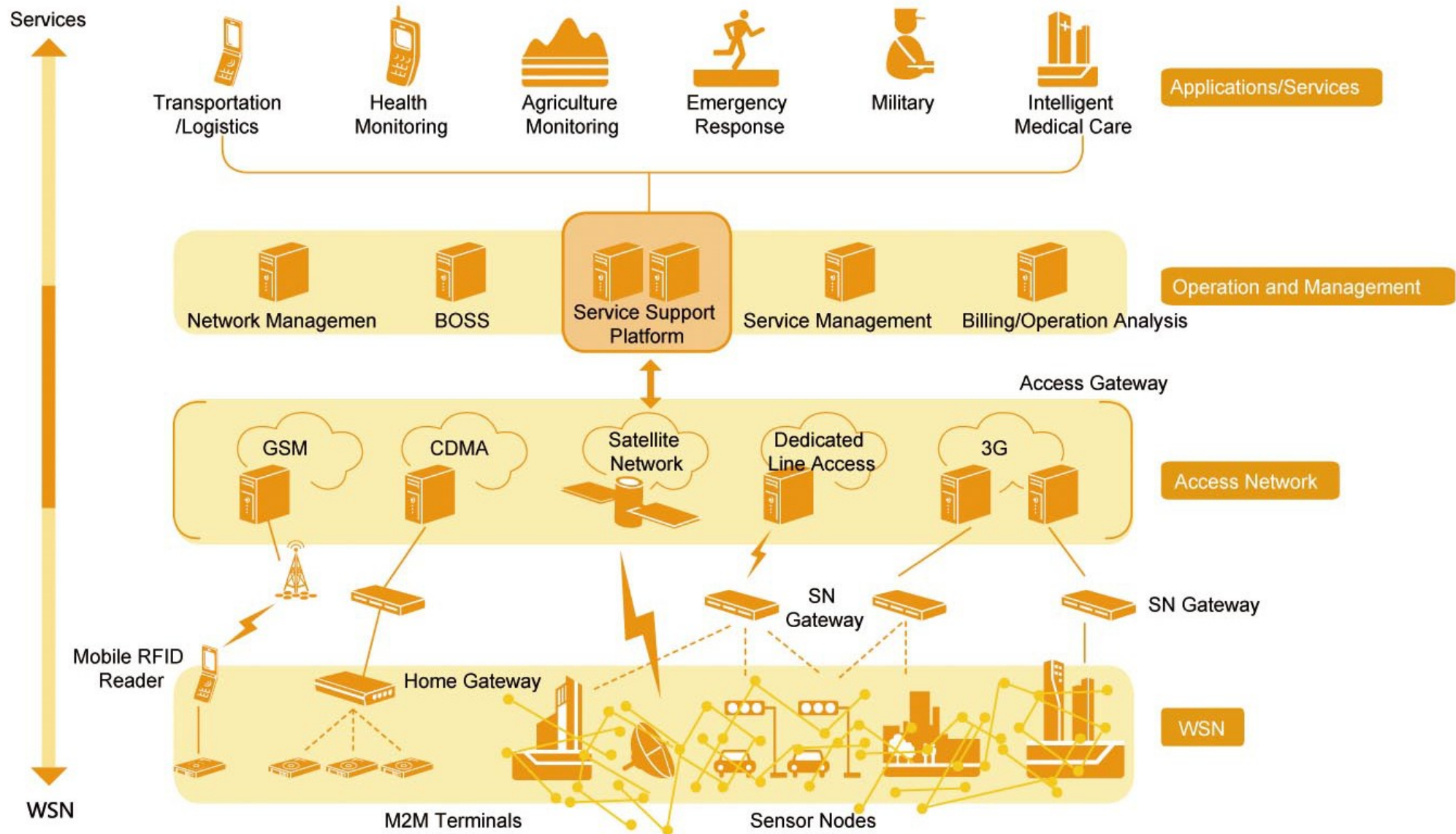
# Ant-based Dynamic Hop Optimization Protocol: a Routing Algorithm for Mobile Wireless Sensor Networks

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# Internet of Things: Challenge

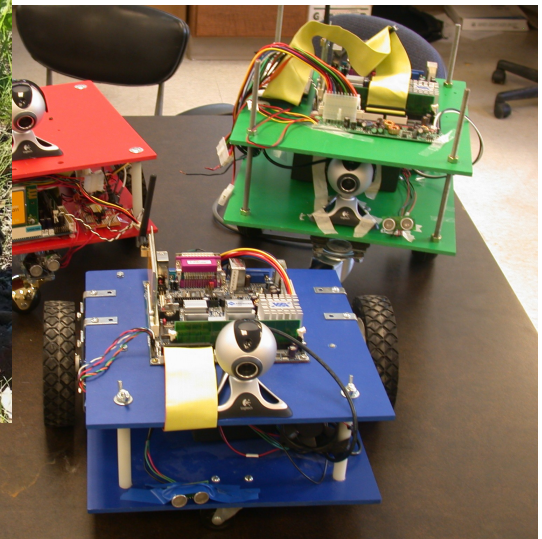


# Smart Object Communication

- Intermittent
- Scalable
- Self-configuring
- Real-time
- Power-aware
- **Mobility**



- Mobile Ad hoc NETworks (MANETs)
  - Networks envisioned to be composed of mobile nodes
  - But its requirements have evolved to a point where solutions for MANETs no longer apply to **Wireless Sensor Networks (WSNs)**, e.g., energy and bandwidth
- Therefore, geographic routing protocols and self-organizing protocols have been highlighted in **Mobile WSNs**

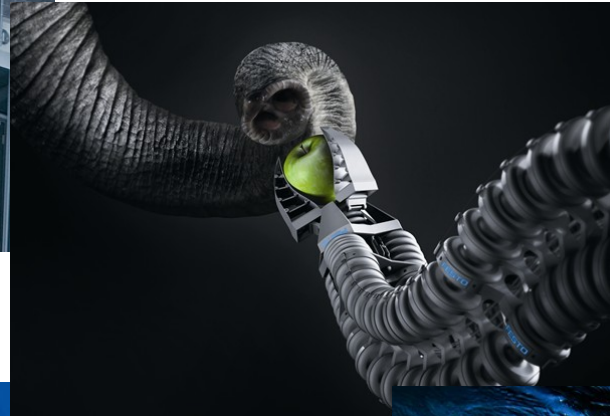




# eBoat at the Brazilian Solar Challenge



# Robotic Animals - Esslingen, Germany



# Ant Colony Optimization (ACO)

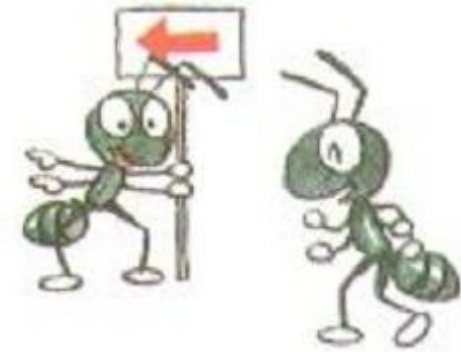
- ACO improves the ability to **adapt** to dynamic topologies
- **Improving** the algorithm in terms of
  - route discovery
  - route maintenance
- And **reducing** the routing **complexity** in WSNs
  - simple routing operations
  - simple routing tables





# Ants

- Ants in routing protocols usually act
  - route **discovery**
  - route **maintenance**



- **pheromone**



- use **simple** operations to route data over the network



# Sensing Pheromone Trail



# Choosing a Route to the Food



# Routing Protocols for Mobile WSNs

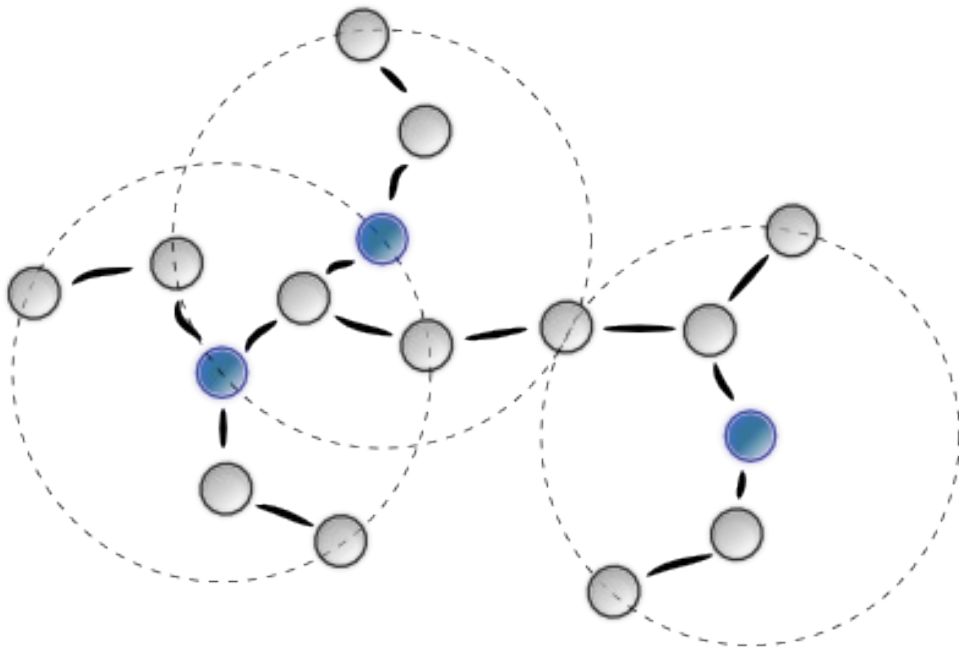


- Ant-based Dynamic Zone Routing Protocol (AD-ZRP) is a routing algorithm **based on** the HOPNET algorithm
  - Developed in Software and Hardware Integration Lab (LISHA), AD-ZRP aims at routing in Mobile WSNs
  
- Noticing the AD-ZRP behavior, and improving some of **its characteristics**, we present **ADHOP**
  - It is a self-organizing and reactive algorithm developed to **support** several routing heuristics and improve the **dissemination** of pheromone on the network



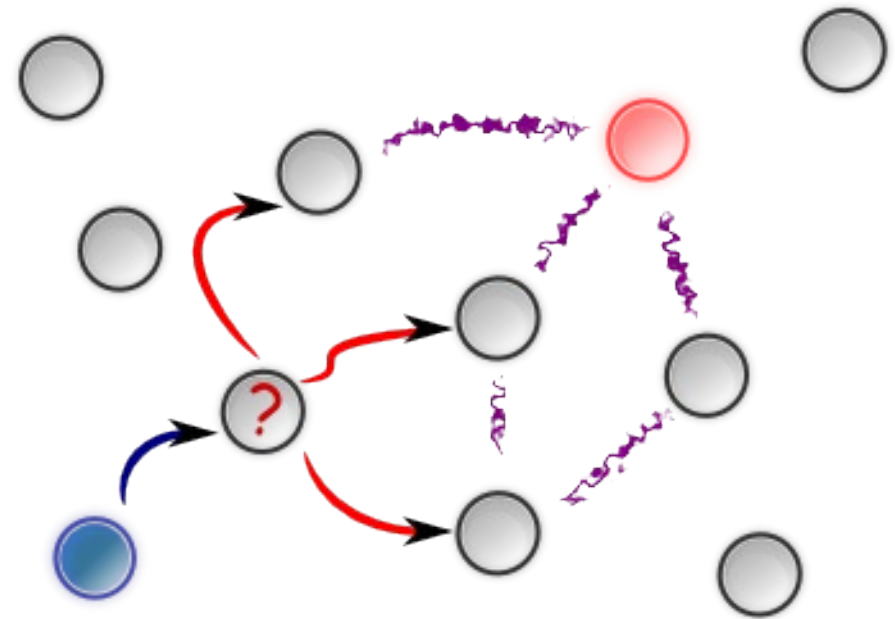
# AD-ZRP ➔ ADHOP

## ■ Ant-based Dynamic Zone Routing Protocol



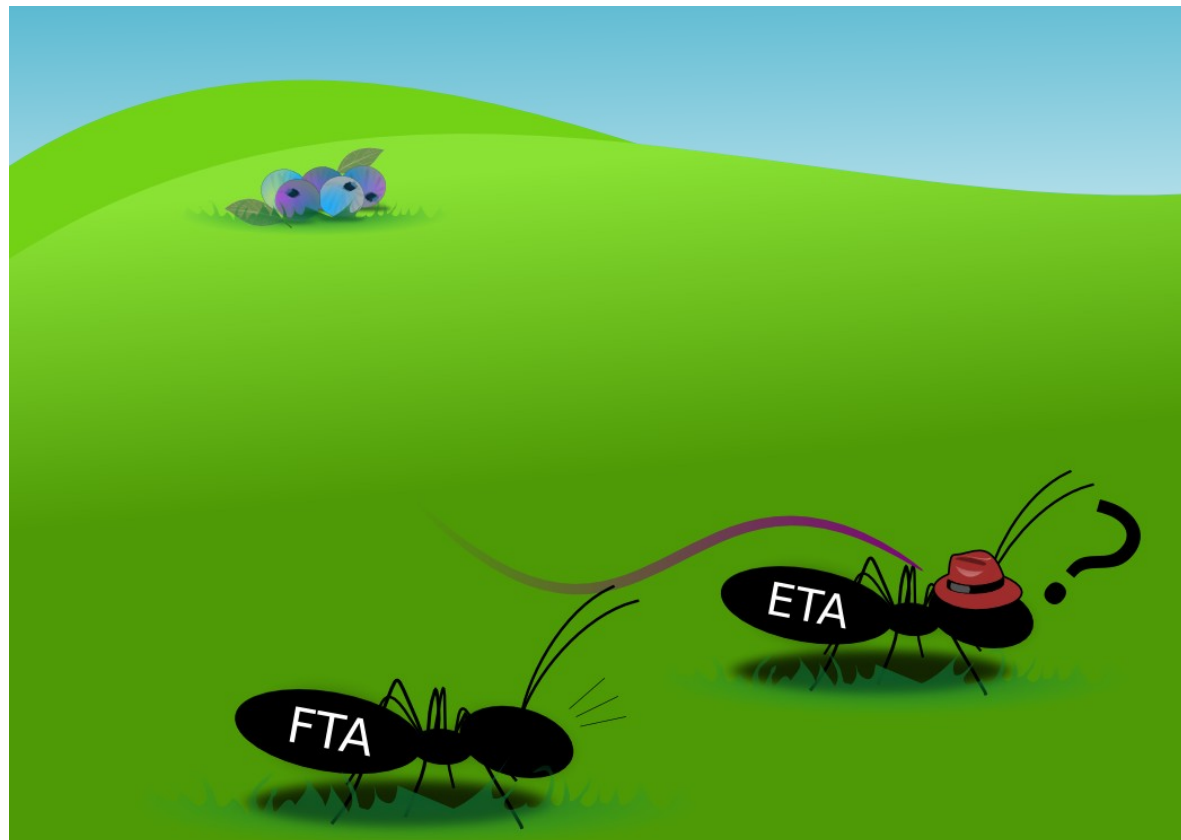
Too much overhead for WSNs

## ■ Ant-based Dynamic Hop Optimization Protocol

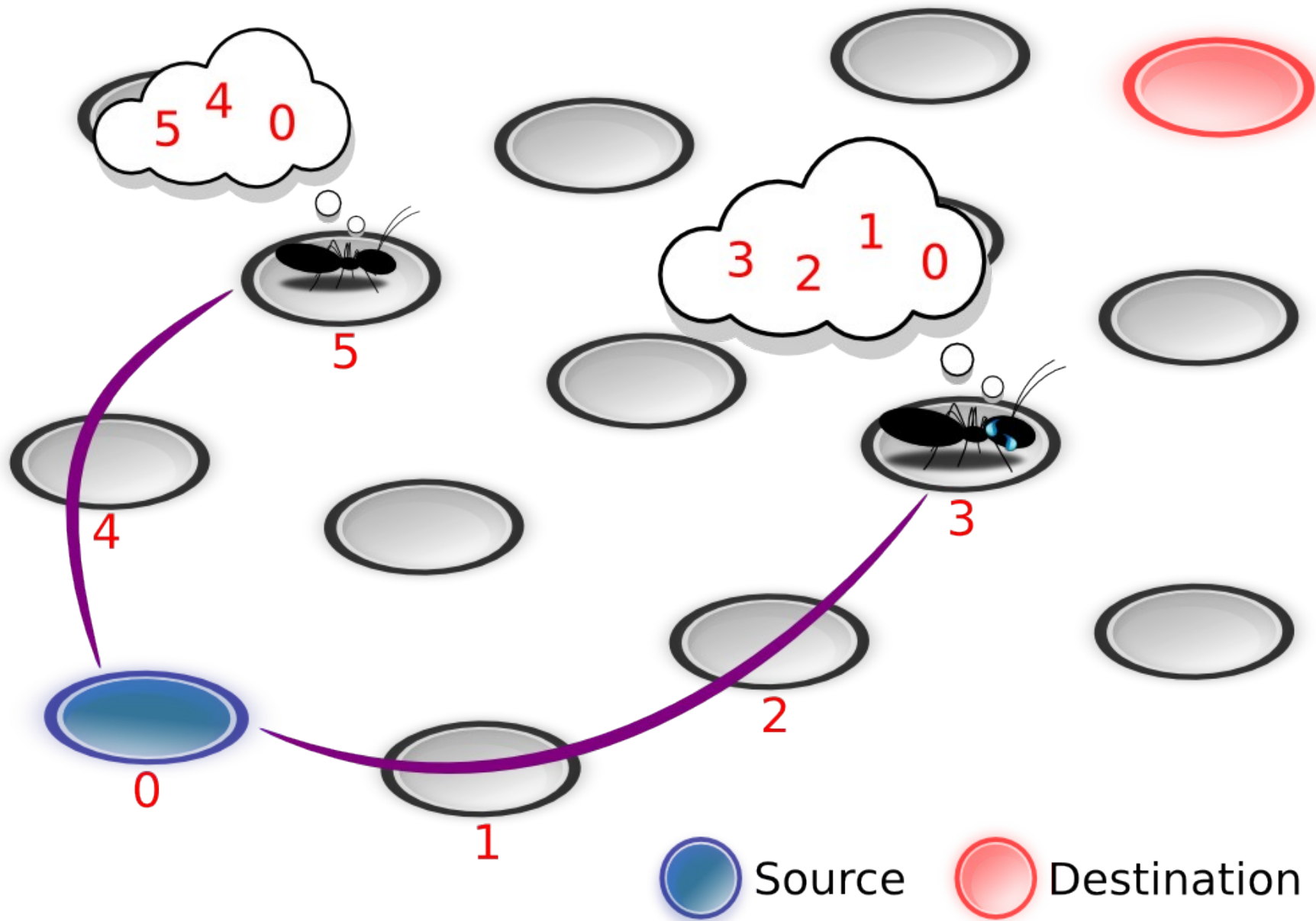


# ADHOP Ants

- Two types of Ants
  - Exploratory Transport Ant (**ETA**)
  - Forward Transport Ant (**FTA**)

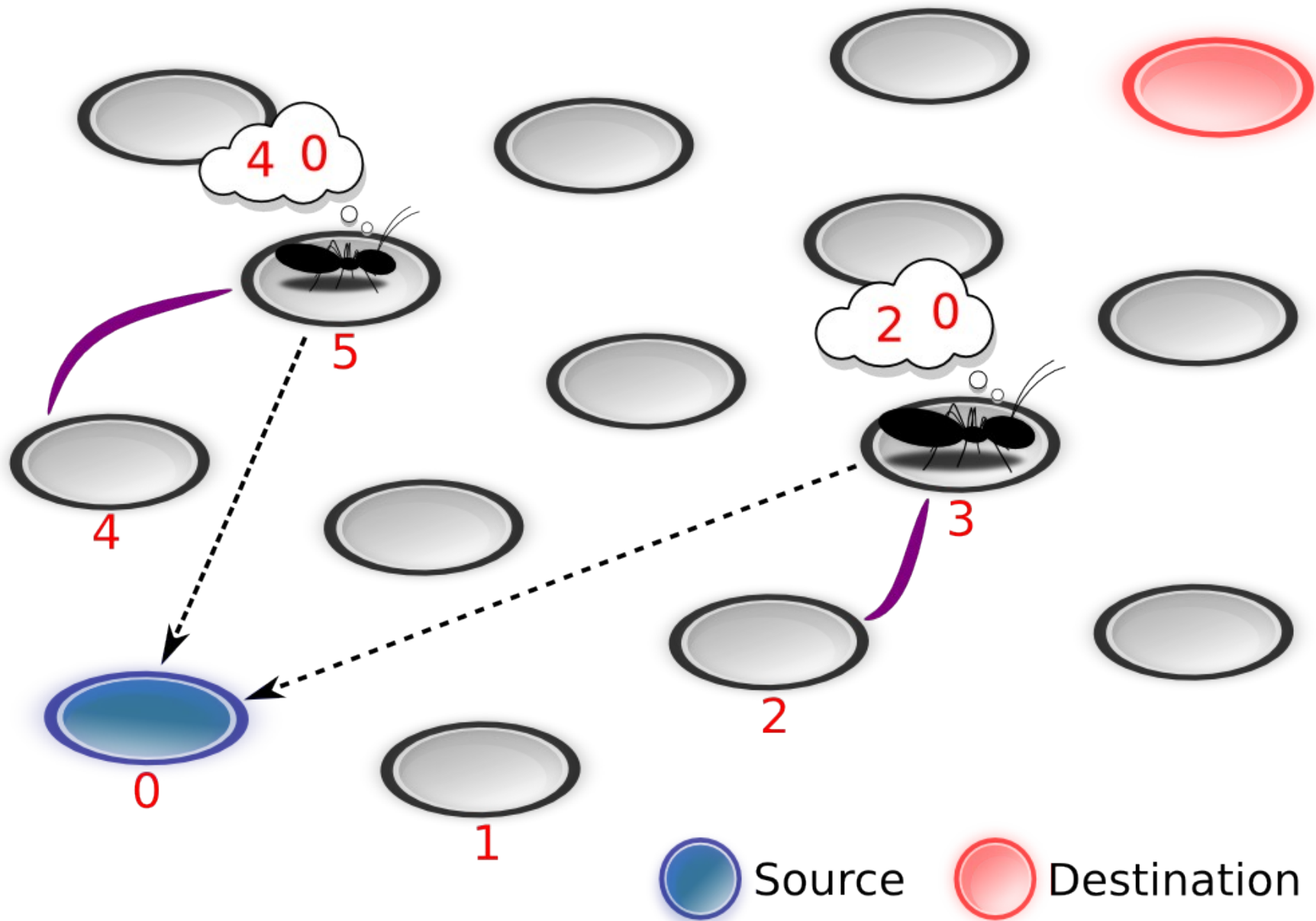


# In Traditional ACO ...

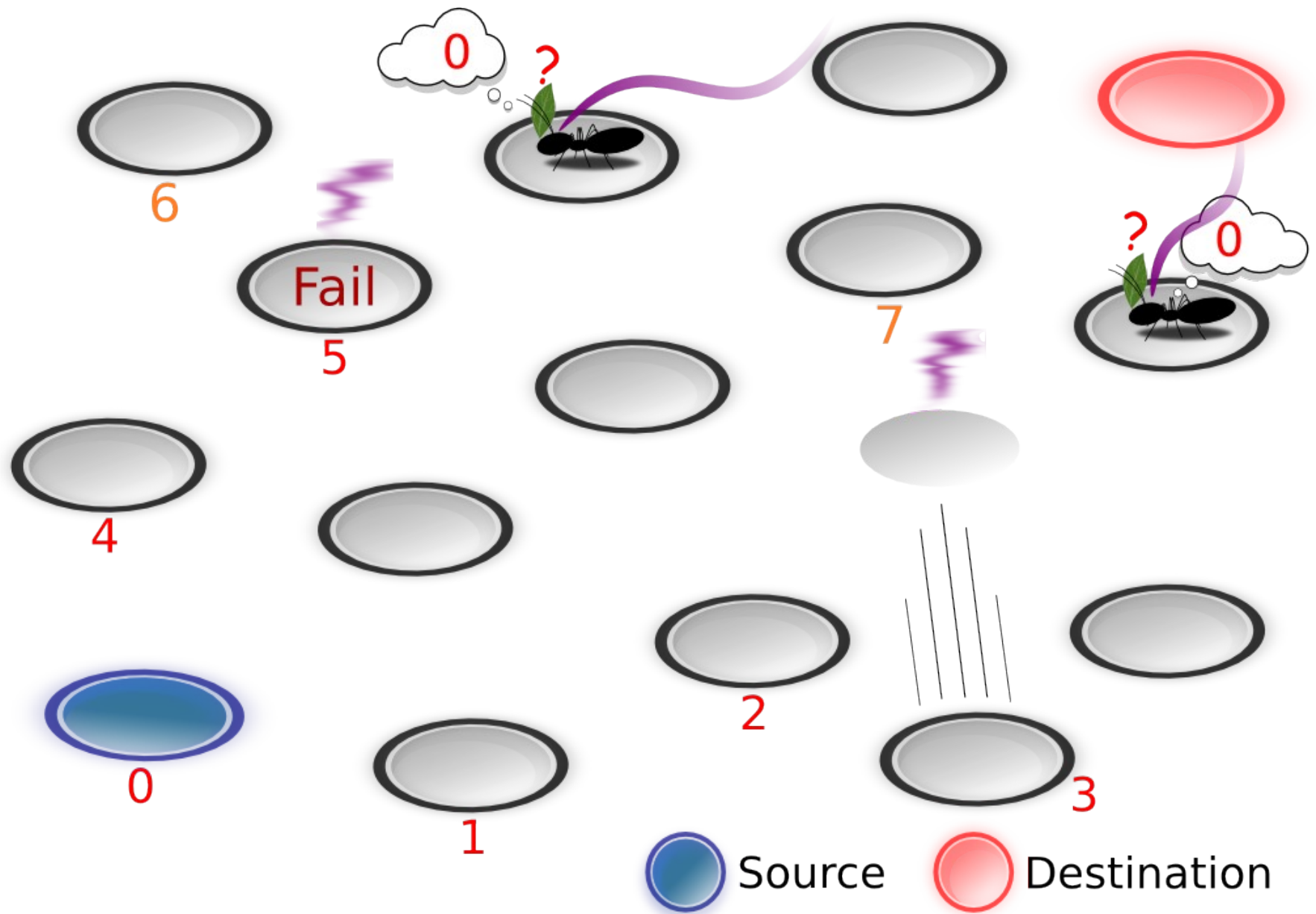




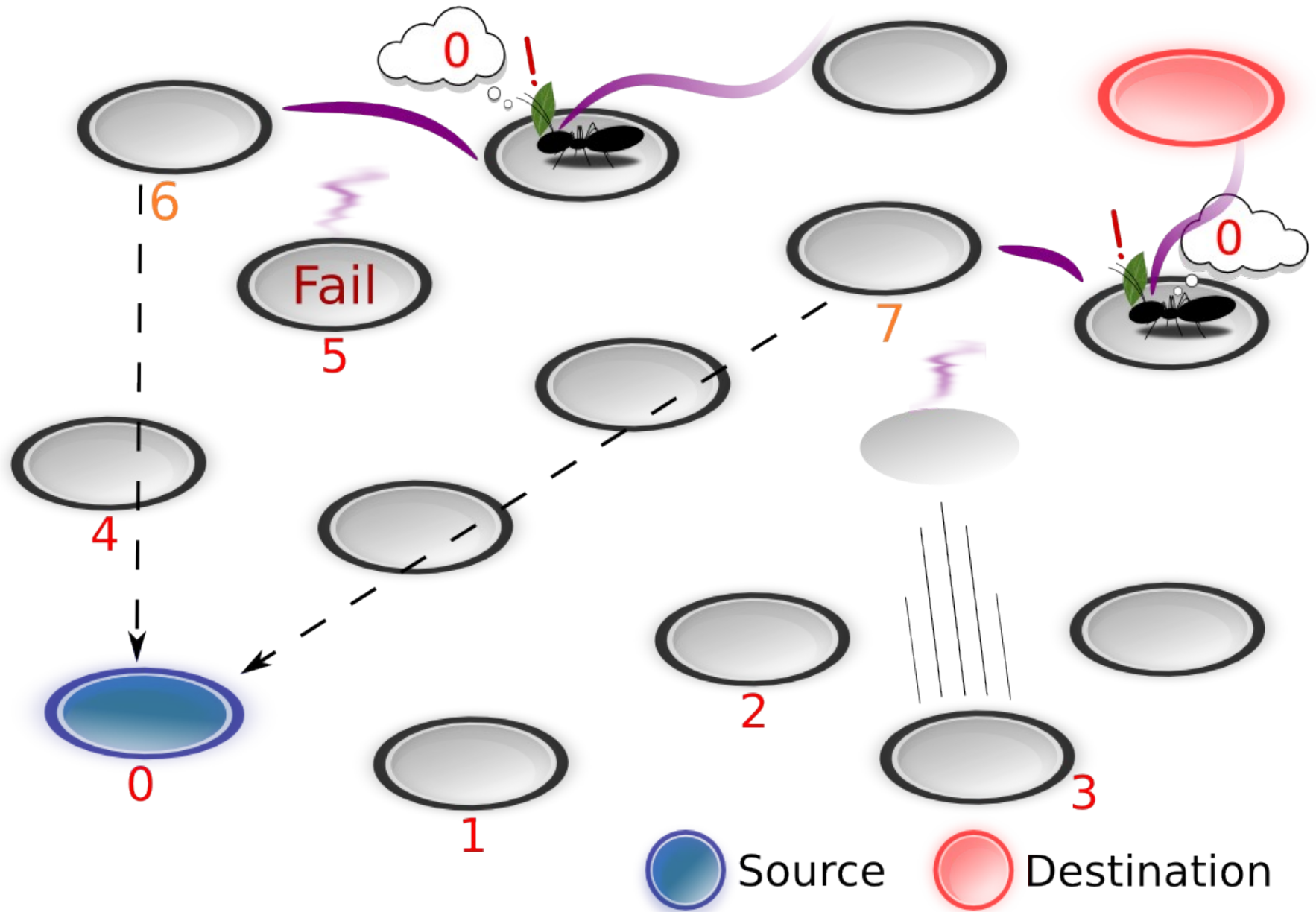
# In ADHOP ...



# Coming back ...



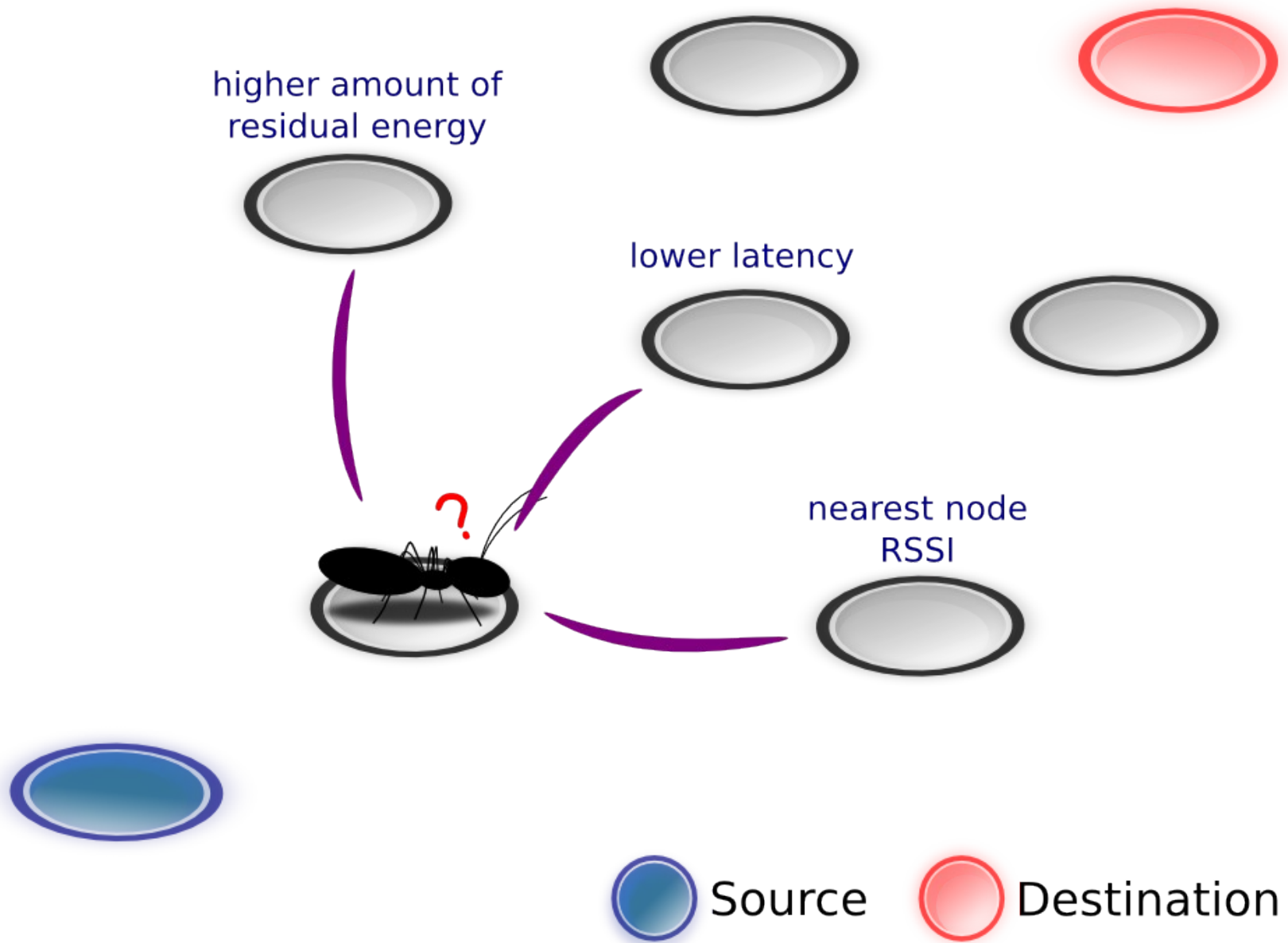
# Coming back ...





# Routing Heuristics

## Deposit and evaporation of pheromone

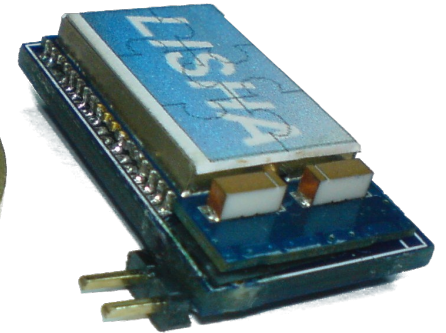


# Implementation in OpenEPOS

<http://epos.lisha.ufsc.br/>

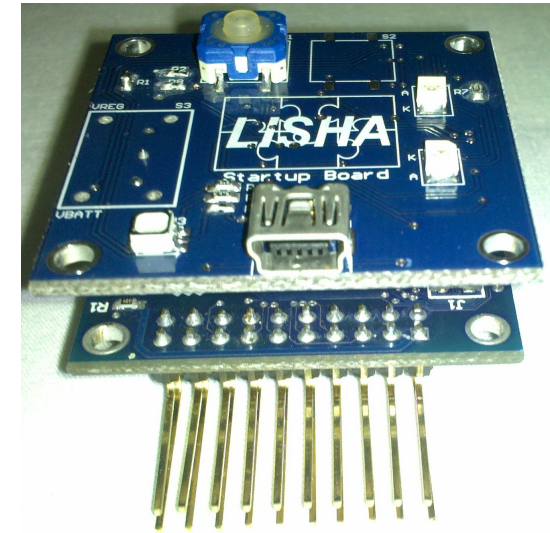


- OpenEPOS **software**
  - RT scheduling, sensing, energy management and communication
- OpenEPOS **hardware**
  - EPOSMote I
    - AVR + ZigBee
  - EPOSMote II
    - AVR + ZigBee / PLC
    - ARM + ZigBee / PLC
- EPOS **gateway** devices
  - GSM / GPRS / Wi-Fi
  - eSDR



# EPOSMote X MicaZ

<http://epos.lisha.ufsc.br/>



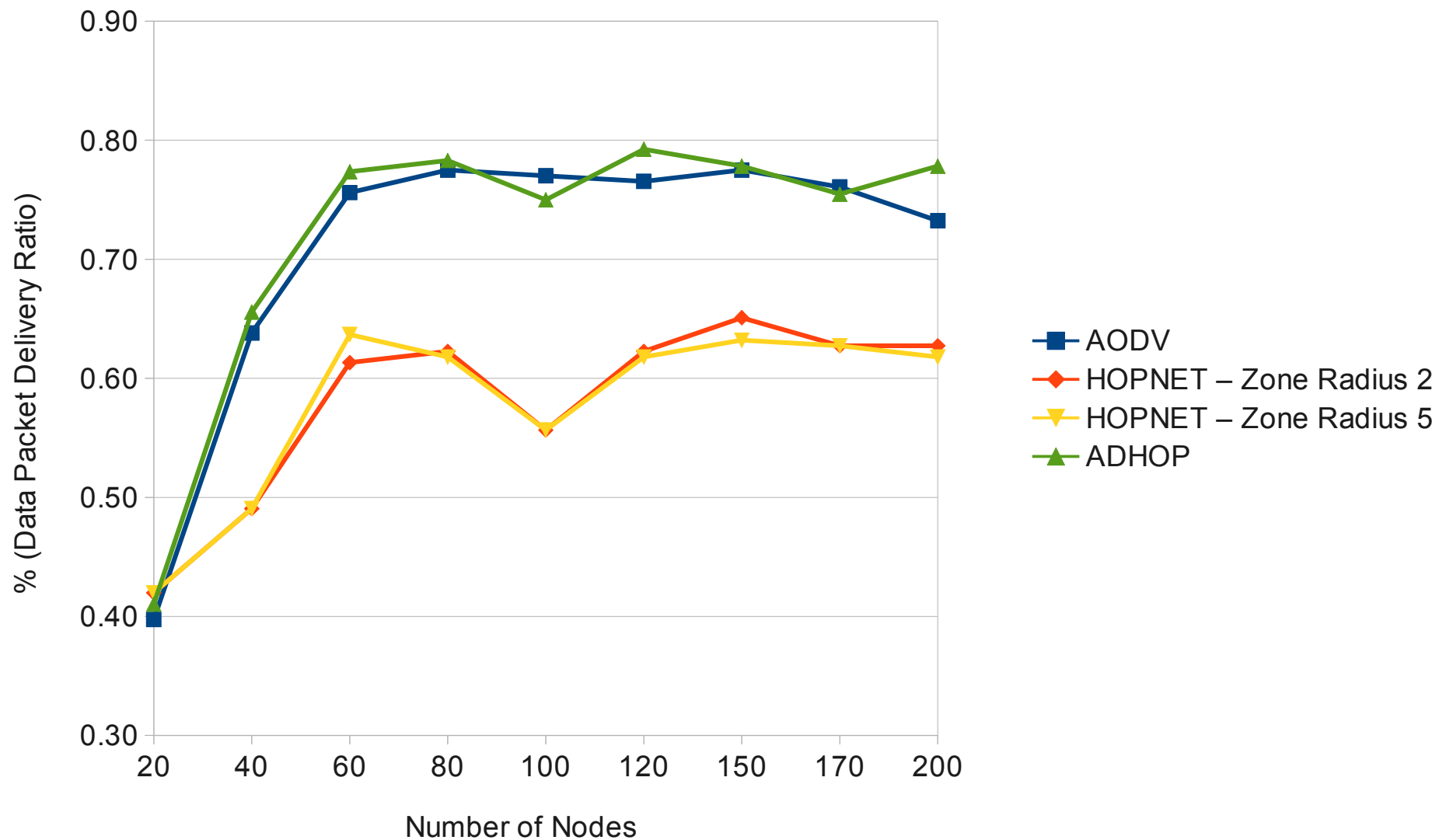
	MicaZ	EPOSMote I	EPOSMote II
Core	PCB	ZigBit	MC13224V
Processor	8-bits ATMega128L	8-bits ATMega128v	32-bits ARM7 TDMI
RAM	4 kB	8 kB	96 kB
Flash	128 kB	128 kB	128 kB
Transmission Power	0 dBm	+3 dBm	+4 dBm
Max Tx Current	17.4 mA	18 mA	29 mA
Max Rx Current	19.7 mA	19 mA	22 mA
Sleep Current	15 uA	6 uA	0.85 uA
Size (mm)	58 x 32 x 7	24 x 13,5 x 2	9,5 x 9,5 x 1,2



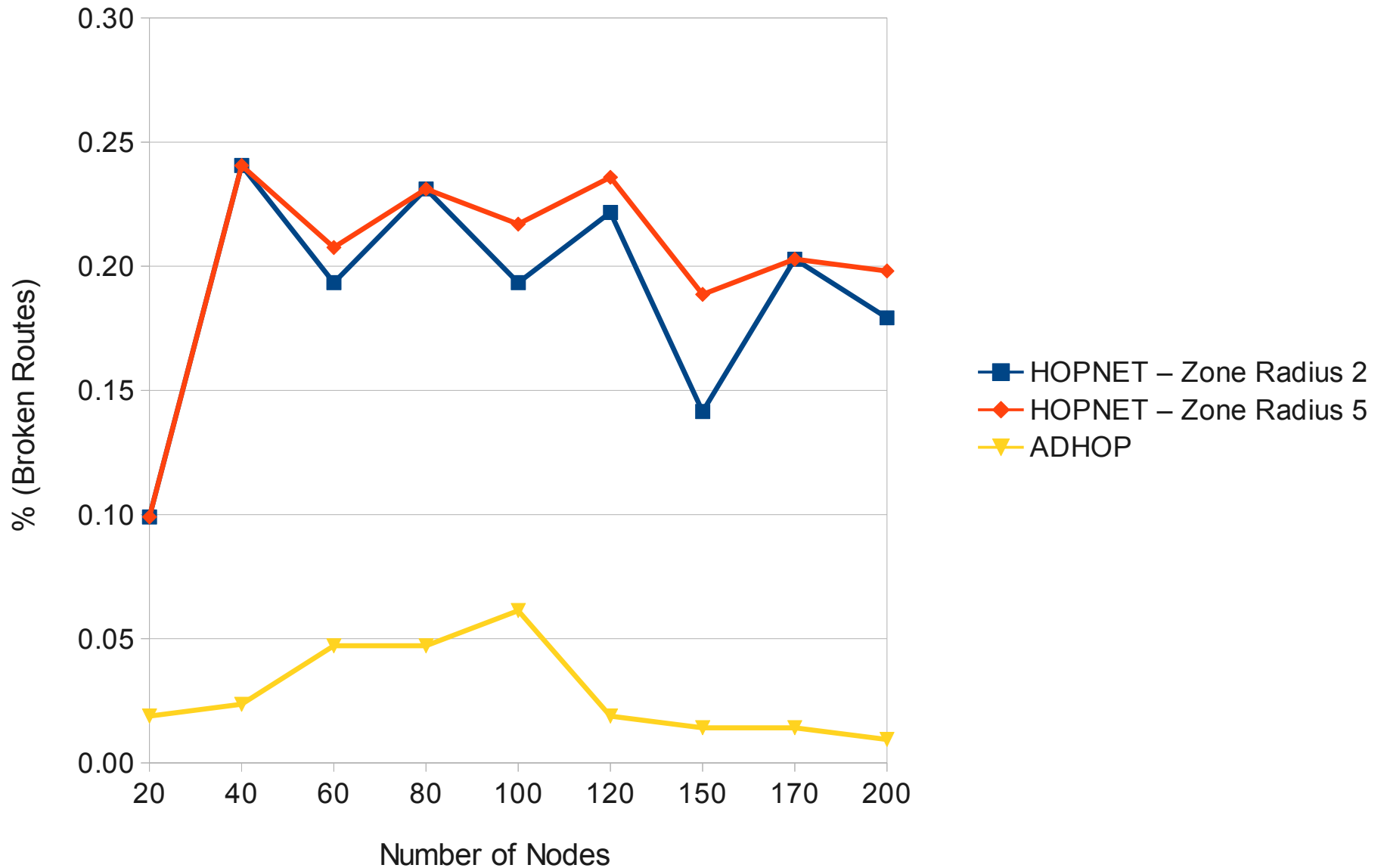
# Simulation 1

- **GloMoSim** (same as HOPNET)
  - 20 to 200 nodes **randomly** moving at 10 m/s on a 700 meters x 400 meters area with high data loss (Random Way Mobility Model)
  - 20 CBR UDP/IP data sources on IEEE 802.11
  - 15 dBm transmission power at 2 Mbps
  - 900 seconds with
- **Not exactly a WSN scenario**, but it enables ADHOP to be compared to **HOPNET**

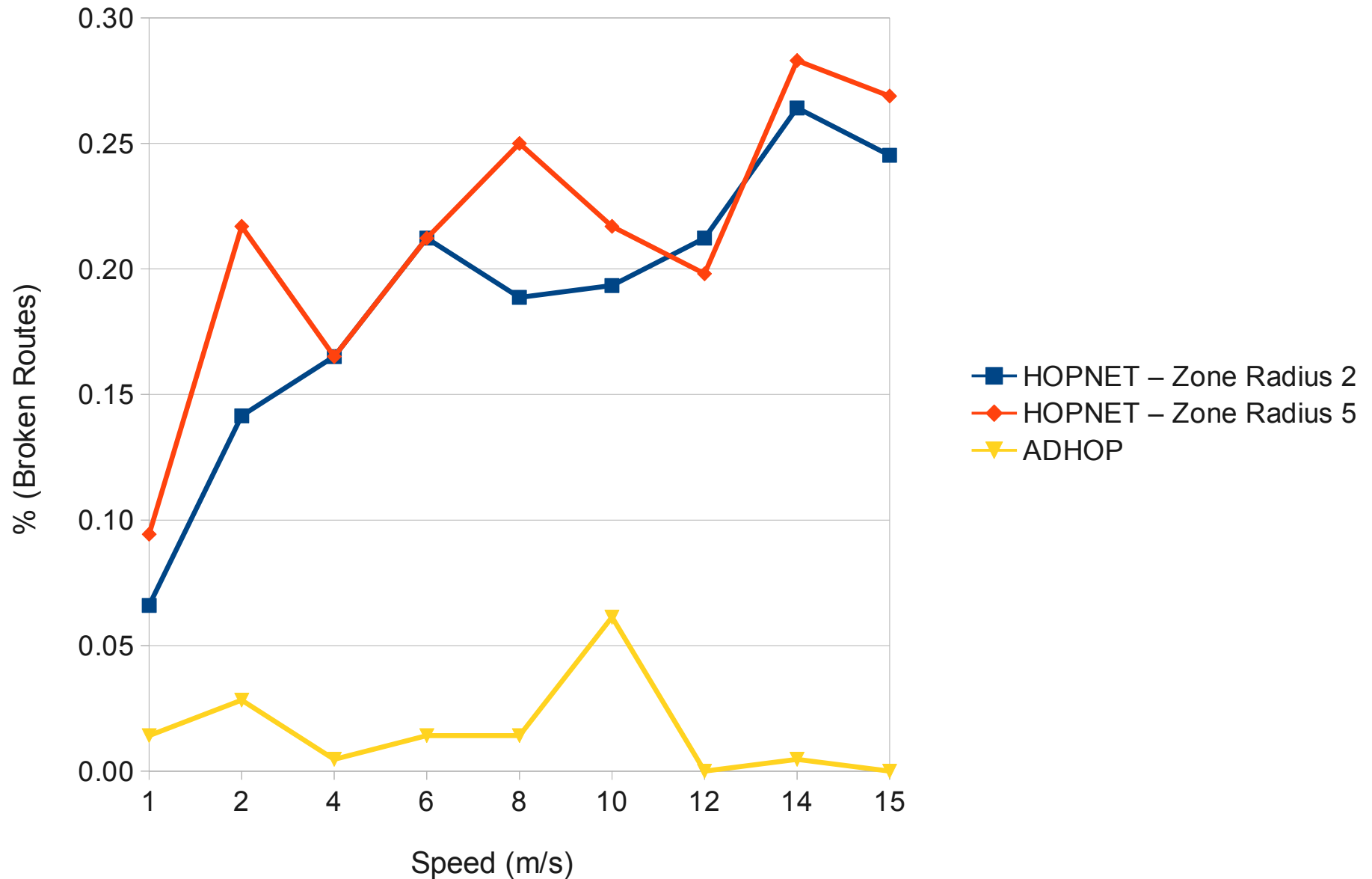
# Data Packet Delivery Ratio



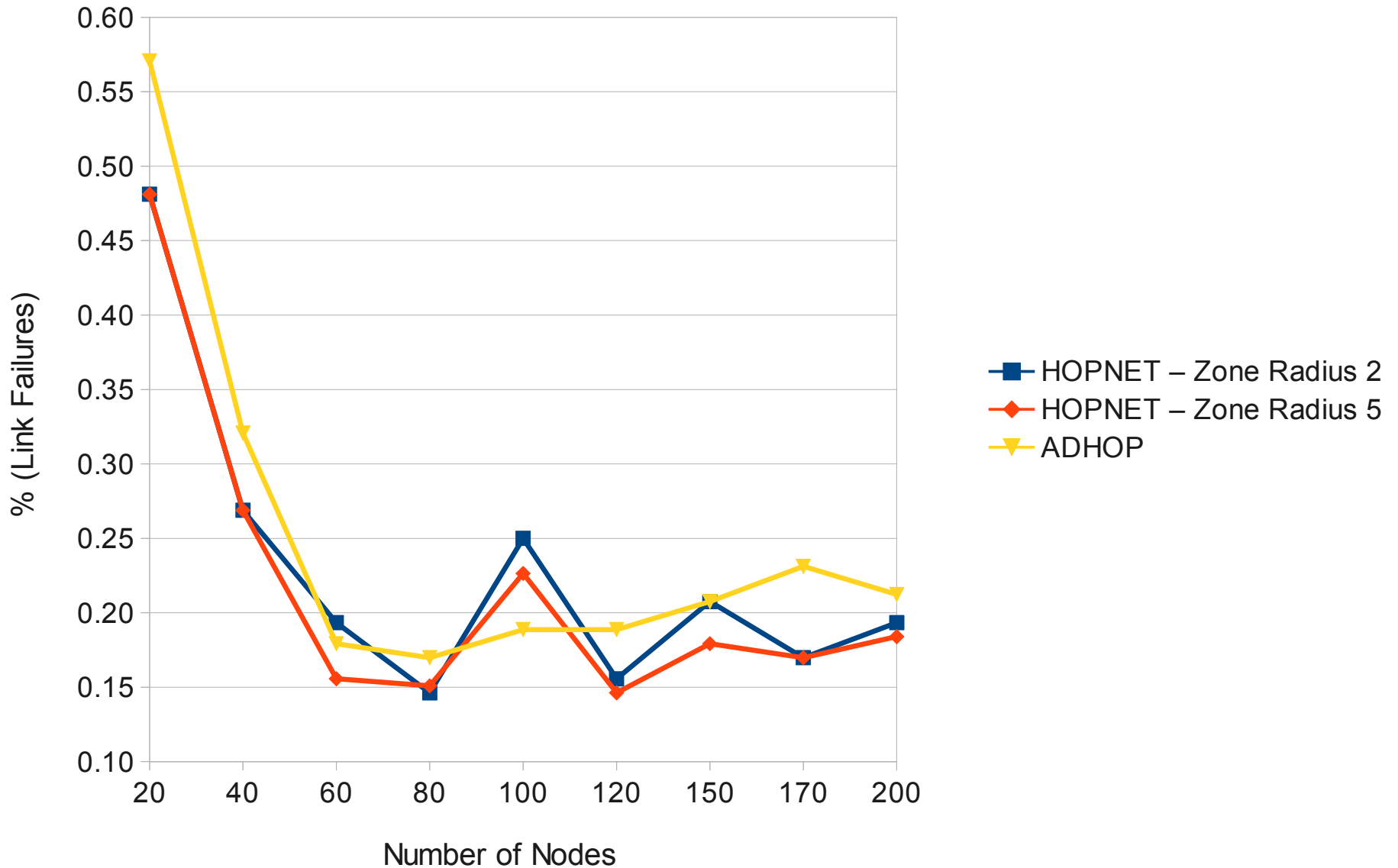
# Broken Routes



# Broken Routes (100 Nodes)

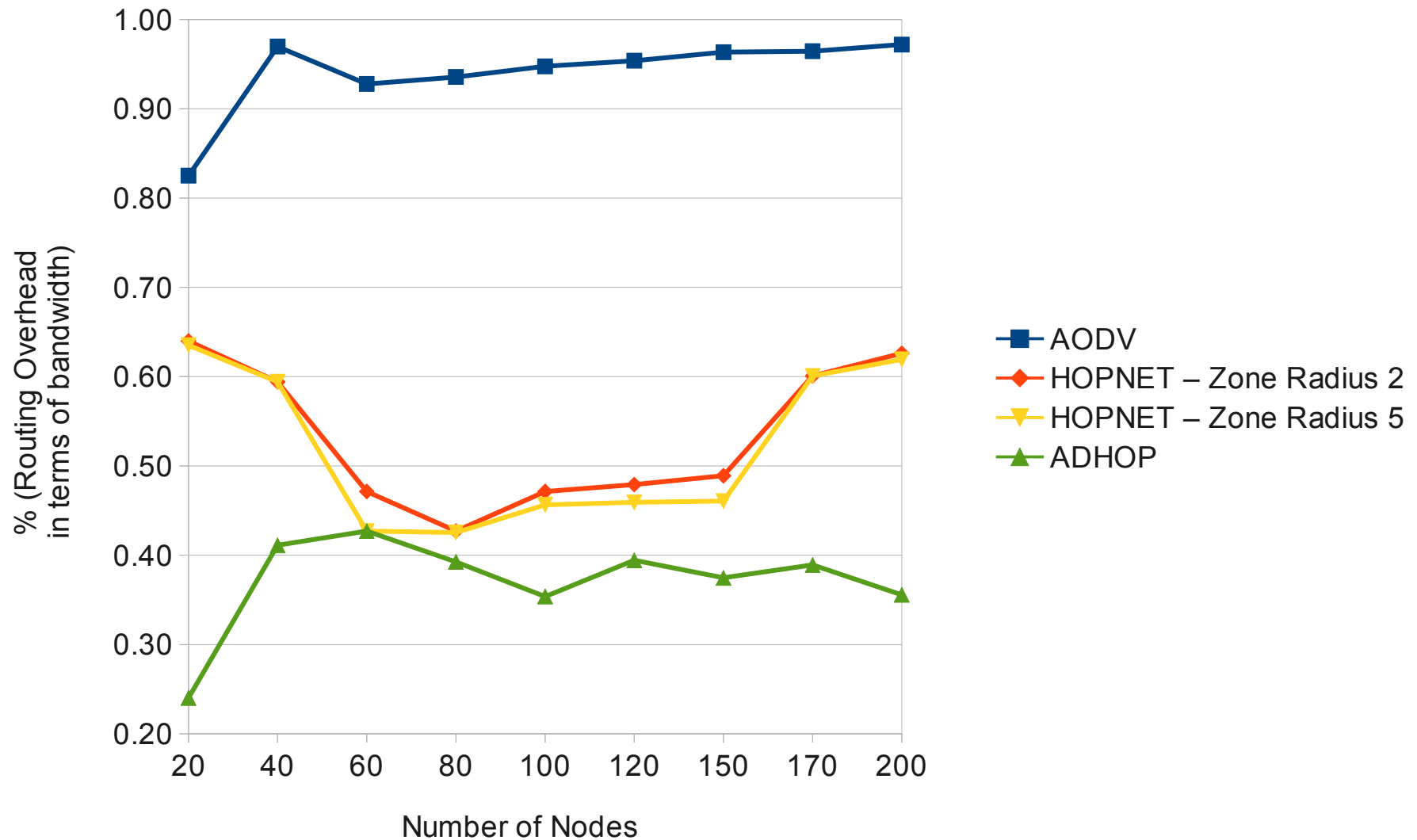


# Link Failures





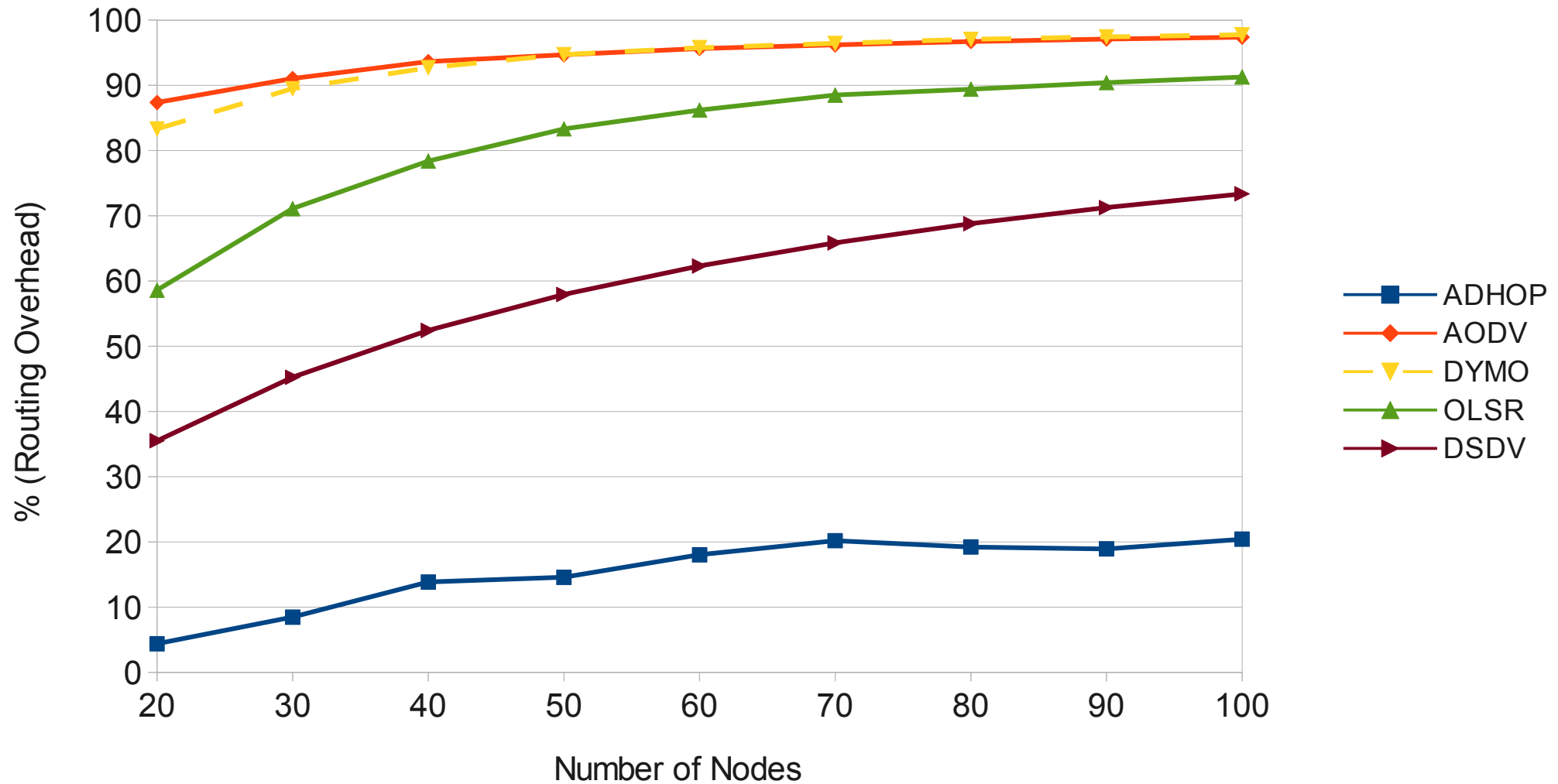
# Routing Overhead



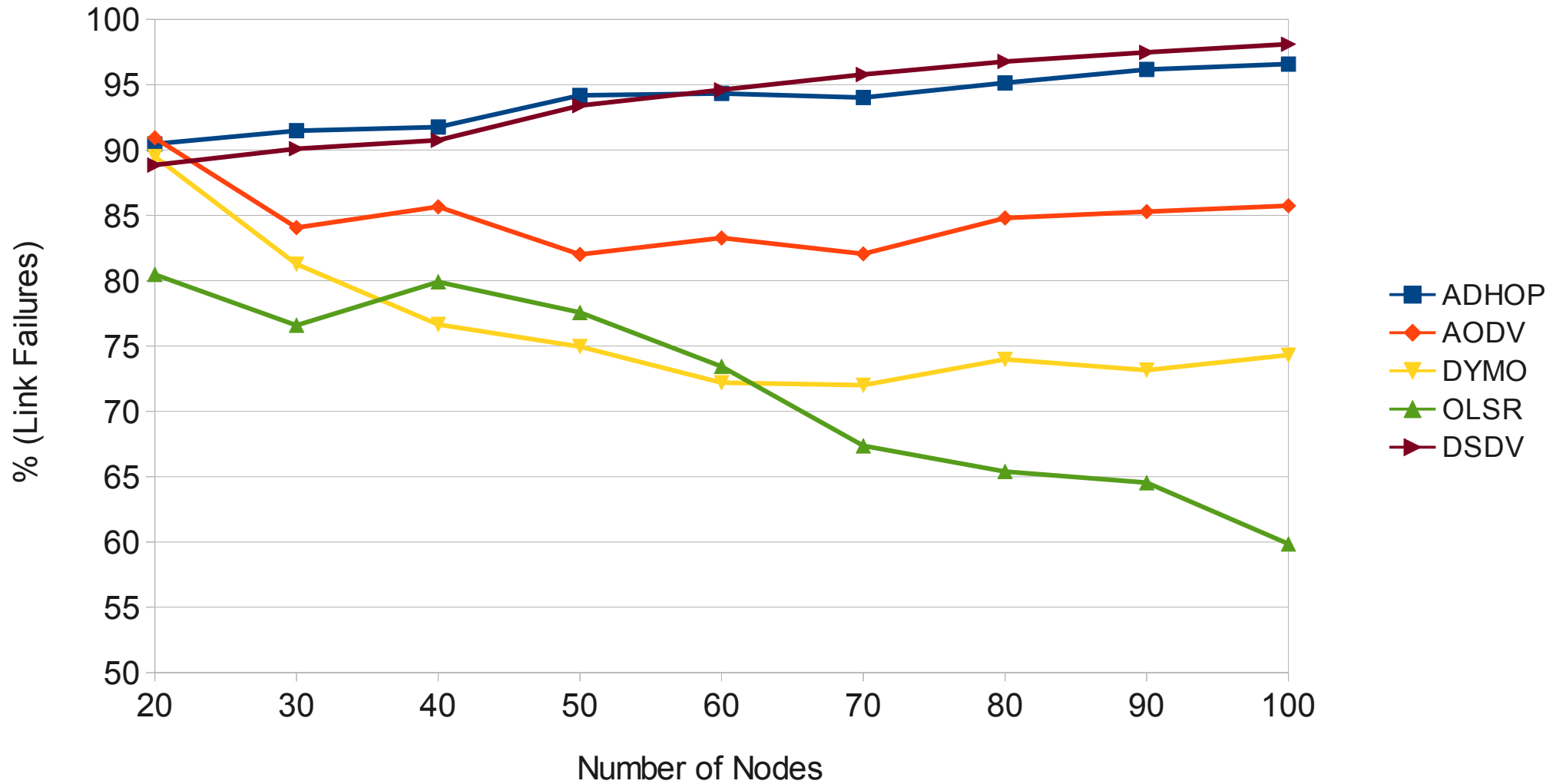
# Simulation 2

- **OMNet++** (WSN scenario-driven)
  - 20 to 100 nodes **randomly** moving at 5 m/s on a 1000 meters x 1000 meters area with **high data loss** (Mass Mobility Model)
  - 20 UDP/IP data sources on IEEE 802.15.4
  - 1 mW transmission power
  - Sensitivity -85 dBm
  - Thermal Noise -110 dBm
  - 300 seconds with
- **IEEE 802.15.4 MTU** (127 bytes)
  - Data/UDP/IP/ADHOP/IEEE 802.15.4 == 102 bytes

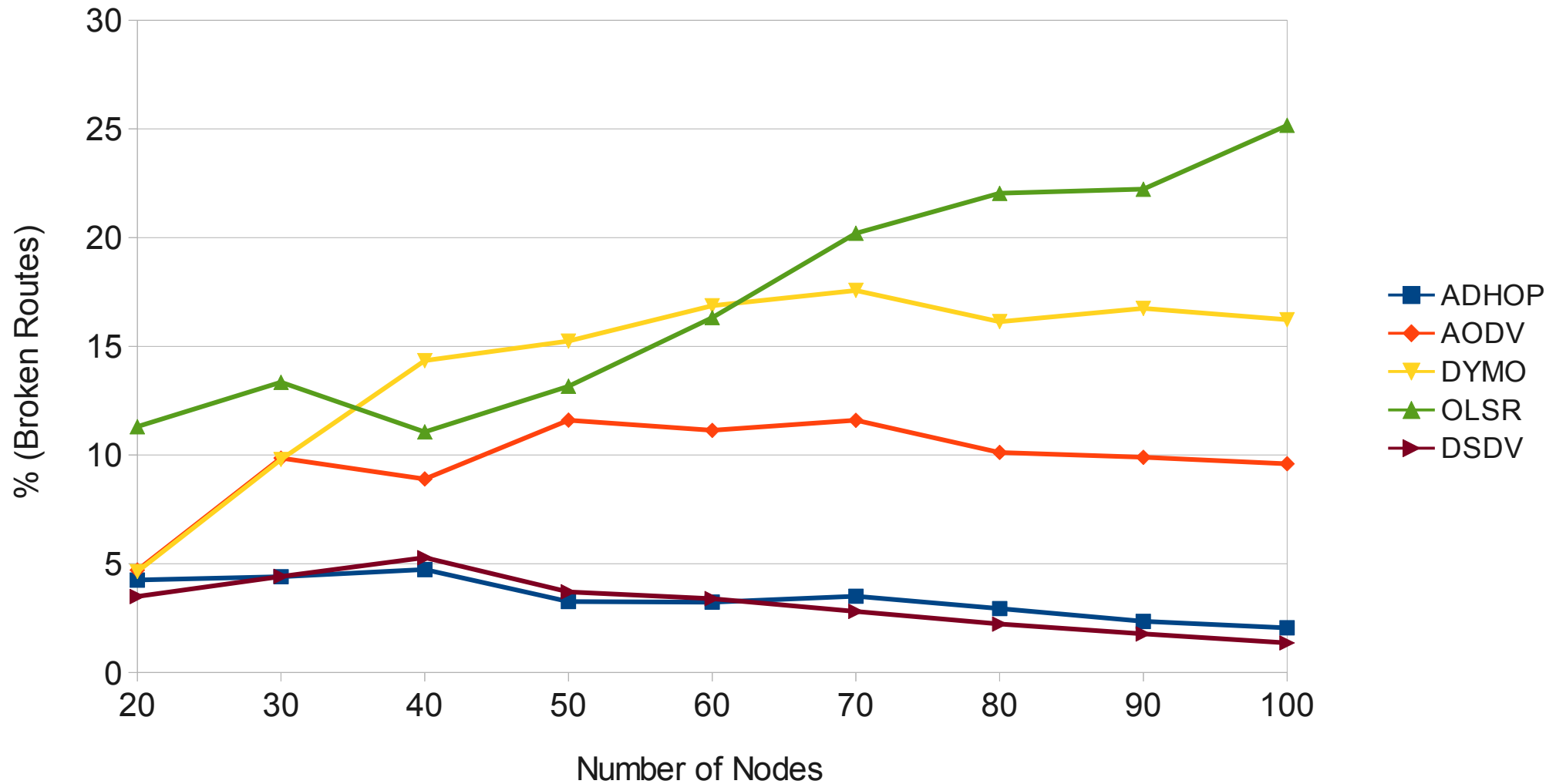
# Routing Overhead



# Link Failures

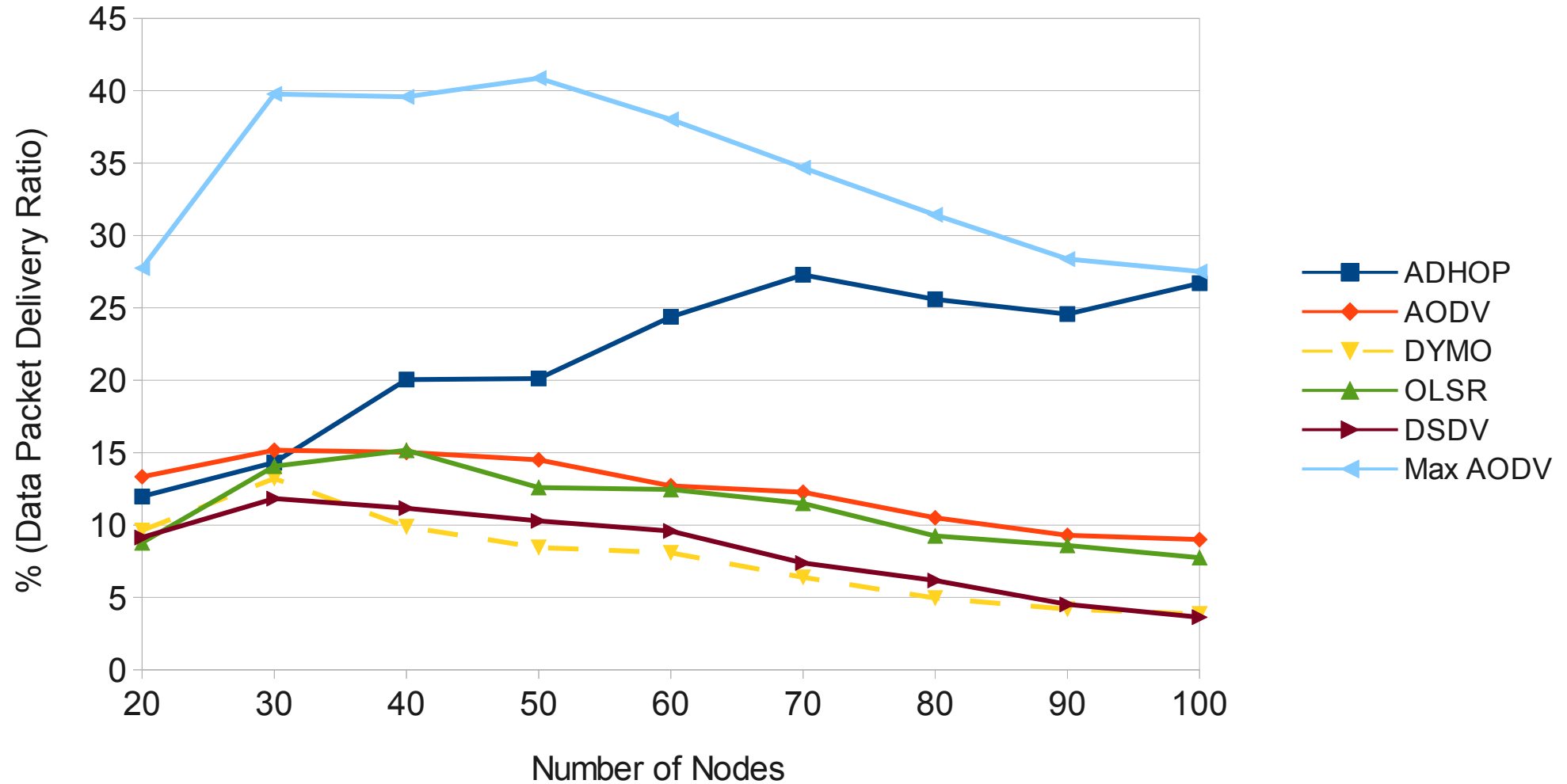


# Broken Routes





# Data Packet Delivery Ratio



# Final Remarks

- ADHOP proves to be an efficient routing algorithm for mobile networks in terms of rate of data delivery
  - And due to its **simplicity** proves to be a good routing algorithm for wireless sensor networks
- Being a reactive algorithm, ADHOP **lacks precision** in the choice of near neighbors
  - However, it has a very low routing overhead
    - And thus **lower power consumption**
- Better integration with **C-MAC** will yield an even lower overhead routing protocol