Expanded ring-based forwarder selection to improve packet delivery in ultra-dense nanonetworks

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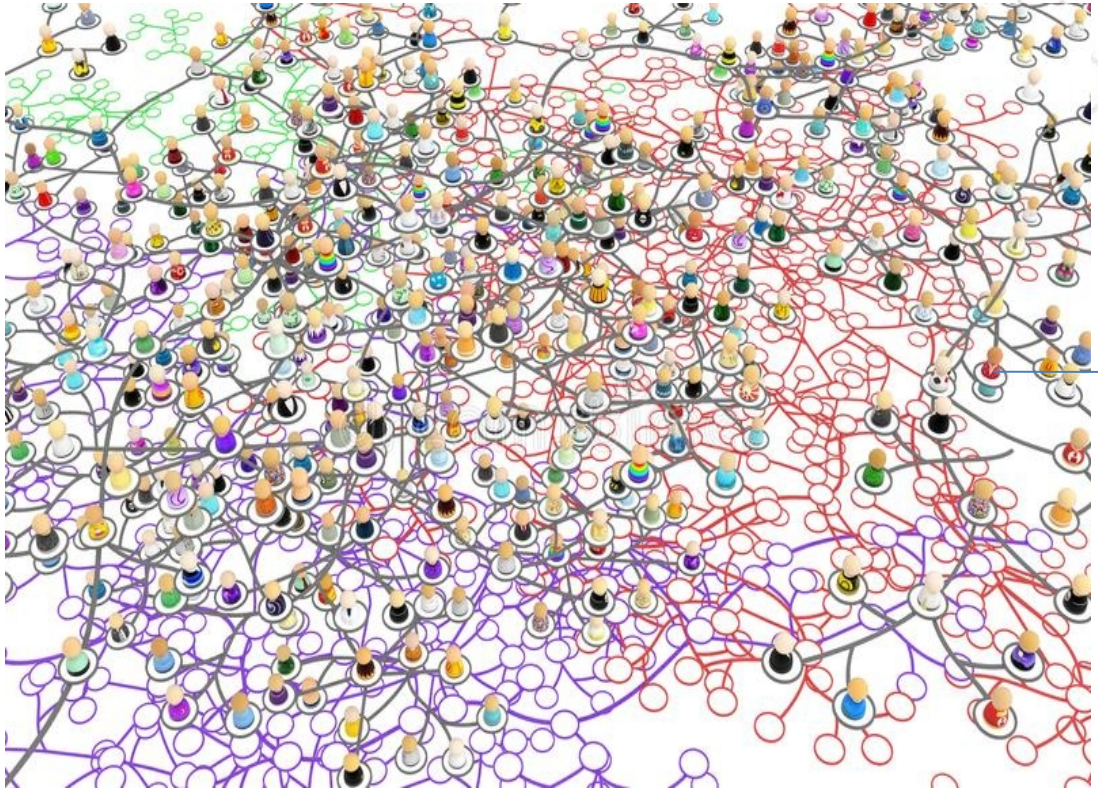
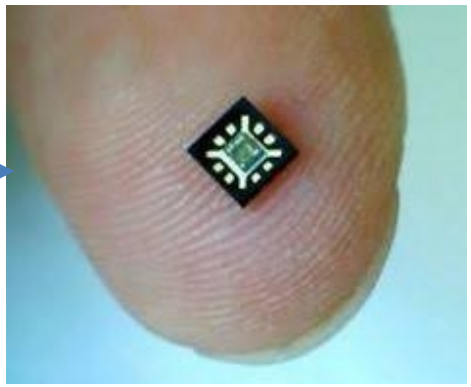
Terabits-per-second wireless communications: Terahertz nanonetworks:

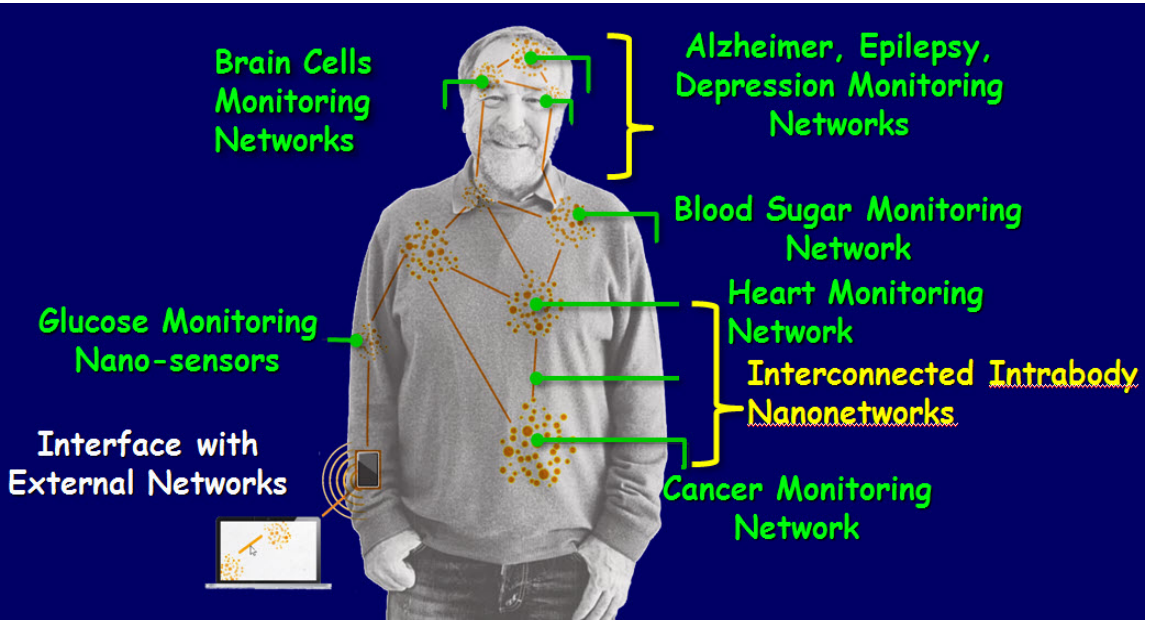




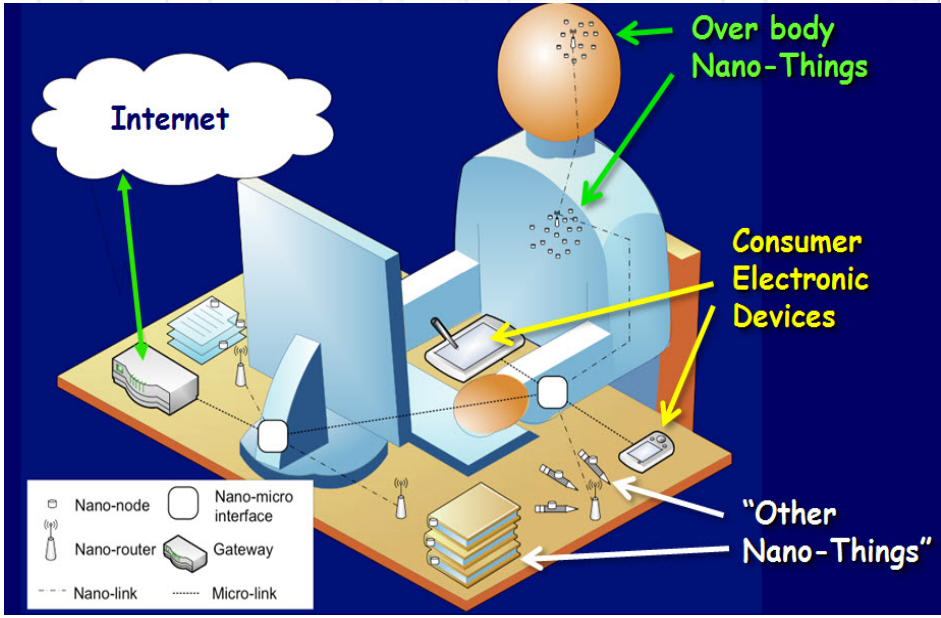
Ultra-dense ad hoc network of tiny nanosensors

How to route if the constrained nanosensor cannot keep up with its dense environement?

Terahertz nanonetworks:



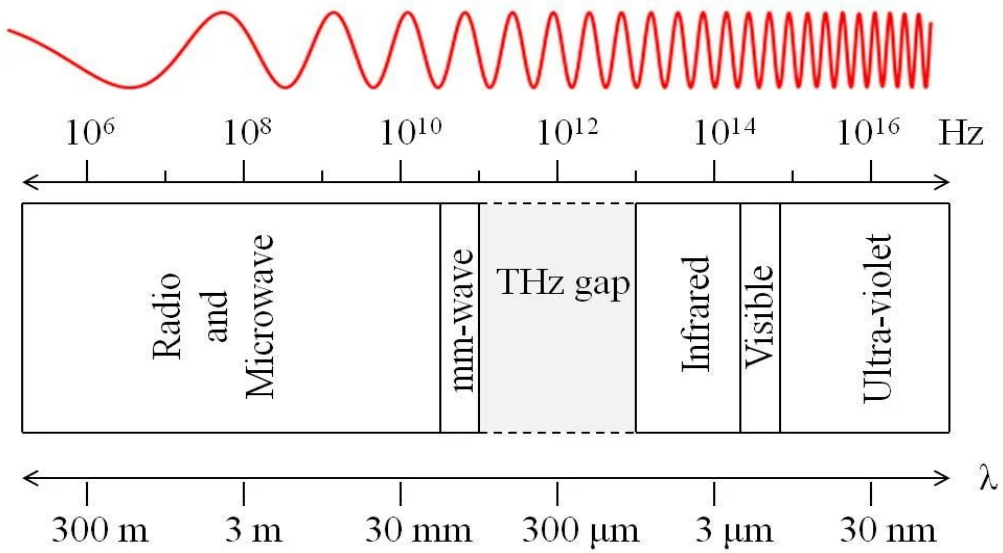
Advanced health systems



Internet of nanothings

(credit: Ian Akyildiz and Josep Jornet)

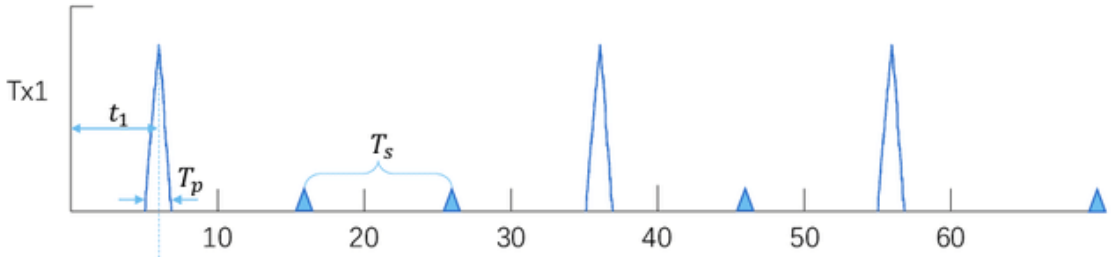
Terahertz nanonetworks:



Communication in the **terahertz frequency** band (0.1–10 THz) using **graphene** antennas.

TS-OOK modulation (Time Spread On-Off Keying): (pulses and not signals with carriers)

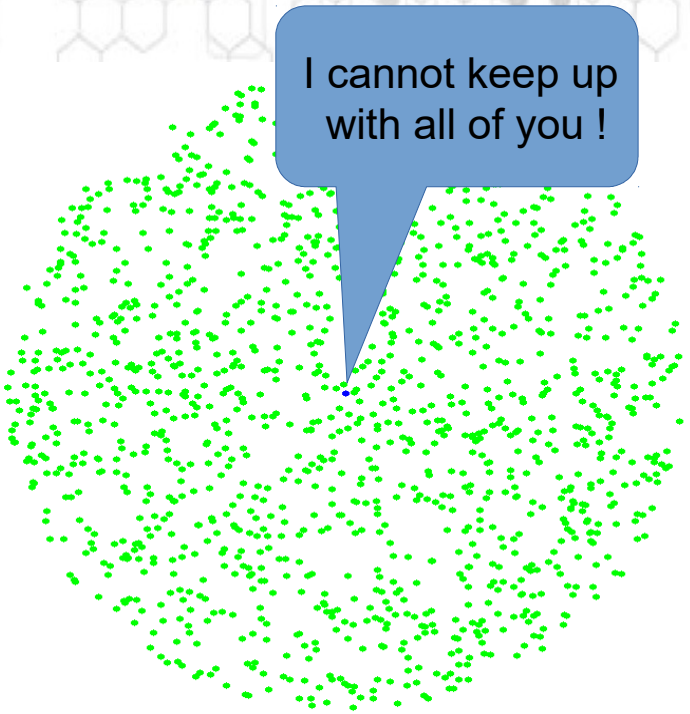
- Bit~1: pulse (energy)
- Bit~0: silence (no energy)



How to route in nanonetworks?

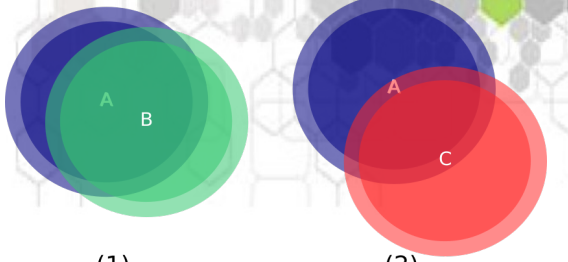
Challenges:

- Large **neighborhood (hundreds or thousands of neighbors).**
- **Incapacity of a node** to retain full neighborhood or network knowledge.
- **Unavailability of location information** (no GPS nor RSSI etc.).



Multi-hop communication: source - forwarders – destination.

Ring-based forwarder selection to improve packet delivery in ultra-dense networks



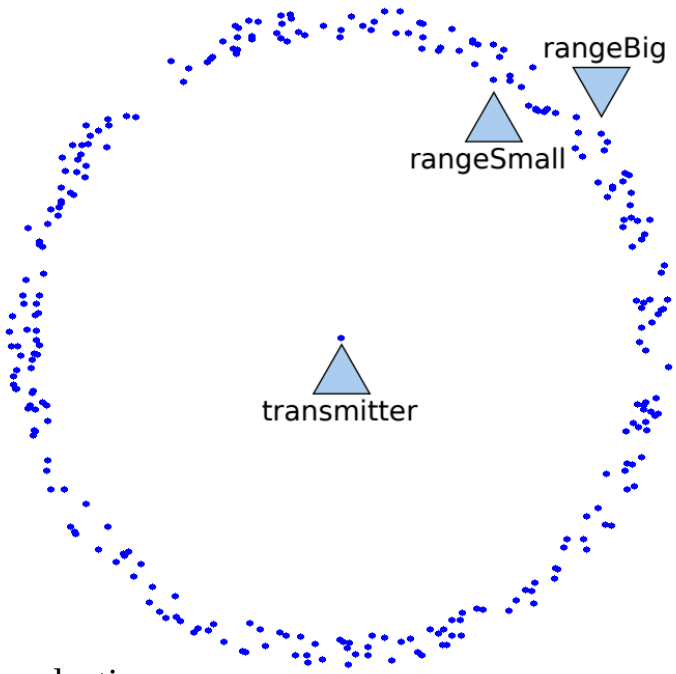
(1) (2)

Making C forward achieves more forwarding progress than B.

Built on top of routing protocols:
<u>On each hop:</u>

- The **transmitter**, at the center of the communication range, sends two **control packets to rangeBig and to rangeSmall.**

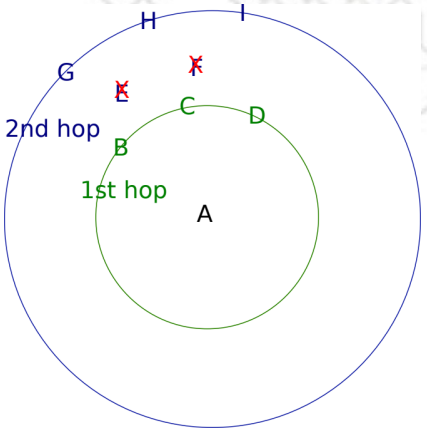
- **Forwarders** are nodes in the **ring** area between rangeBig and rangeSmall **+** selected by the **routing protocol.**

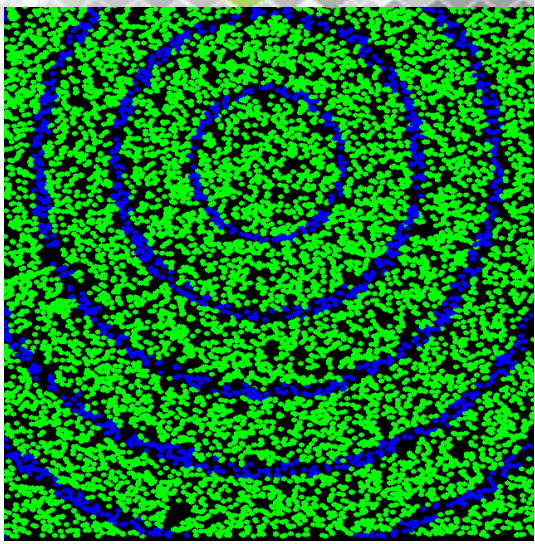


Expanded ring-based forwarder selection to improve packet delivery in ultra-dense nanonetworks

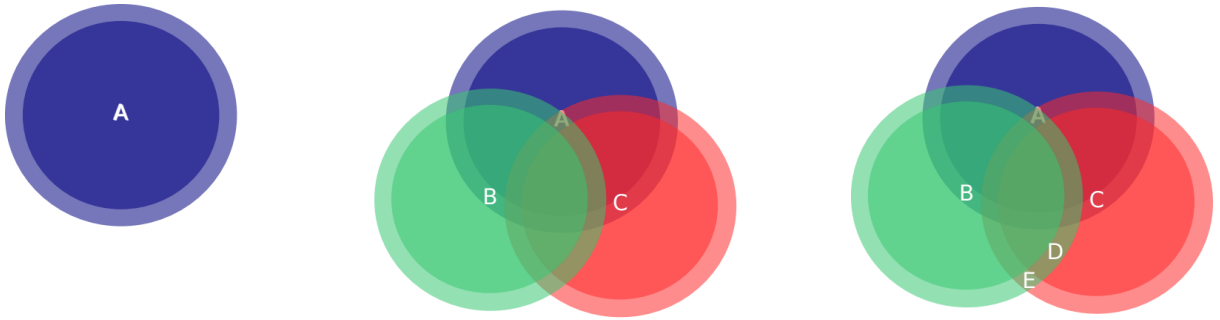
Multi-hop improvement of ring

The expanded ring further reduces the number of forwarders by redefining the ring neighbours and limiting them to those laying at the intersection of rings (while the ring neighbours in the basic ring are found on any ring).





Envisioned goal of the expanded ring.



(1) (2) (3)

Expanded ring: only E is a Forwarder (ON ring for Time window). Basic ring: nodes D and E are forwarders.

Expanded Ring simulations:

Bitsimulator: A scalable electromagnetic nanonetworks simulator

A **source** node generates a CBR flow of packets to:

1) **Broadcast** it to the **whole network** in the first simulation (pure flooding).
2) **Send** it to a **destination node** in the second simulation (SLR).

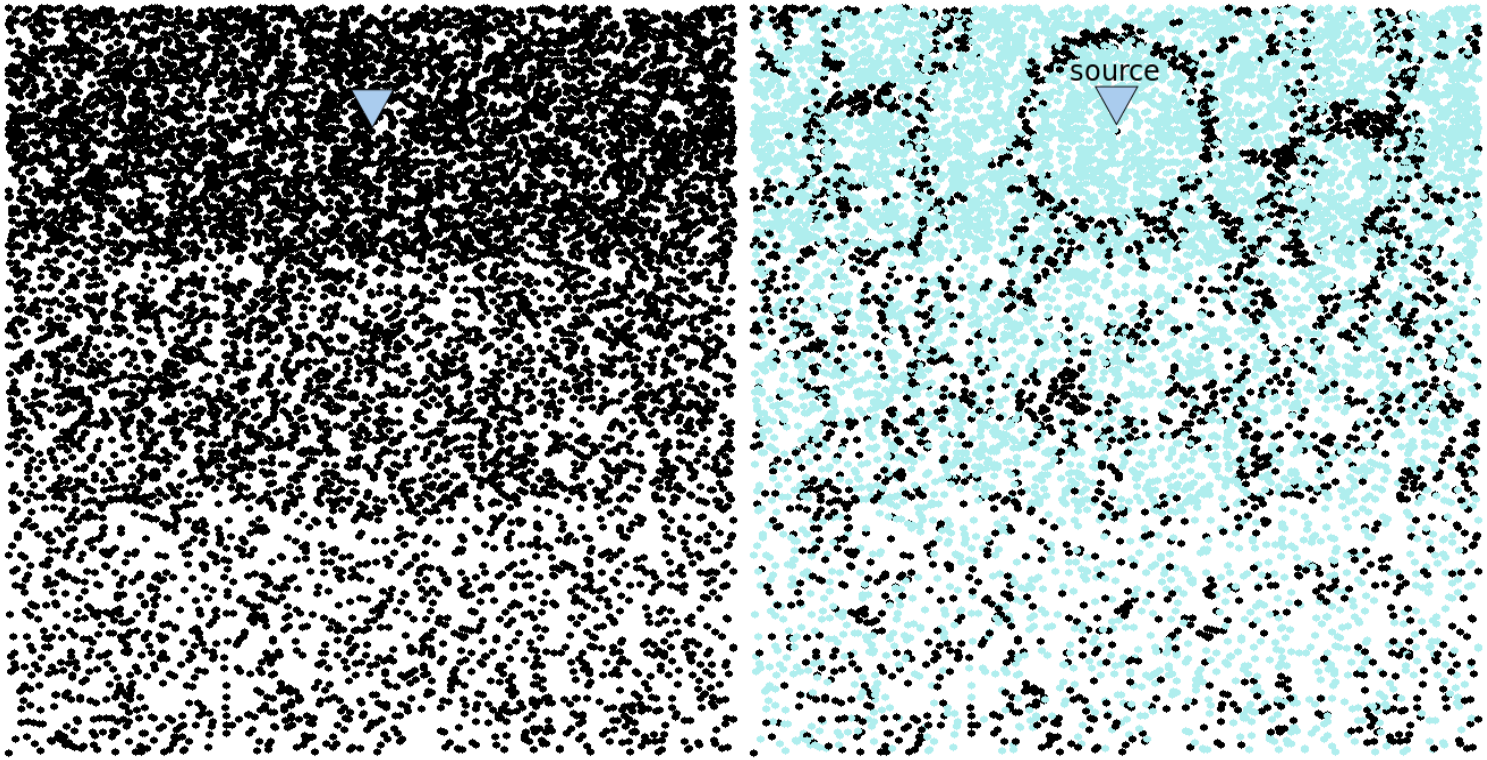
- **Shadowing** propagation model
- **Heterogenous** network
- **TS-OOK** modulation

http://eugen.dedu.free.fr/bitsimulator/

Scenario

parameter	value
Size of simulated area	6 mm * 6 mm
Number of nodes	10 000
Communication range = RangeBig	1000 µm
RangeSmall	830 µm
Average number of neighbors per node	906
Data packet size	1 003 bit
Control packets size	101, 102 bit
Time window	200 ns

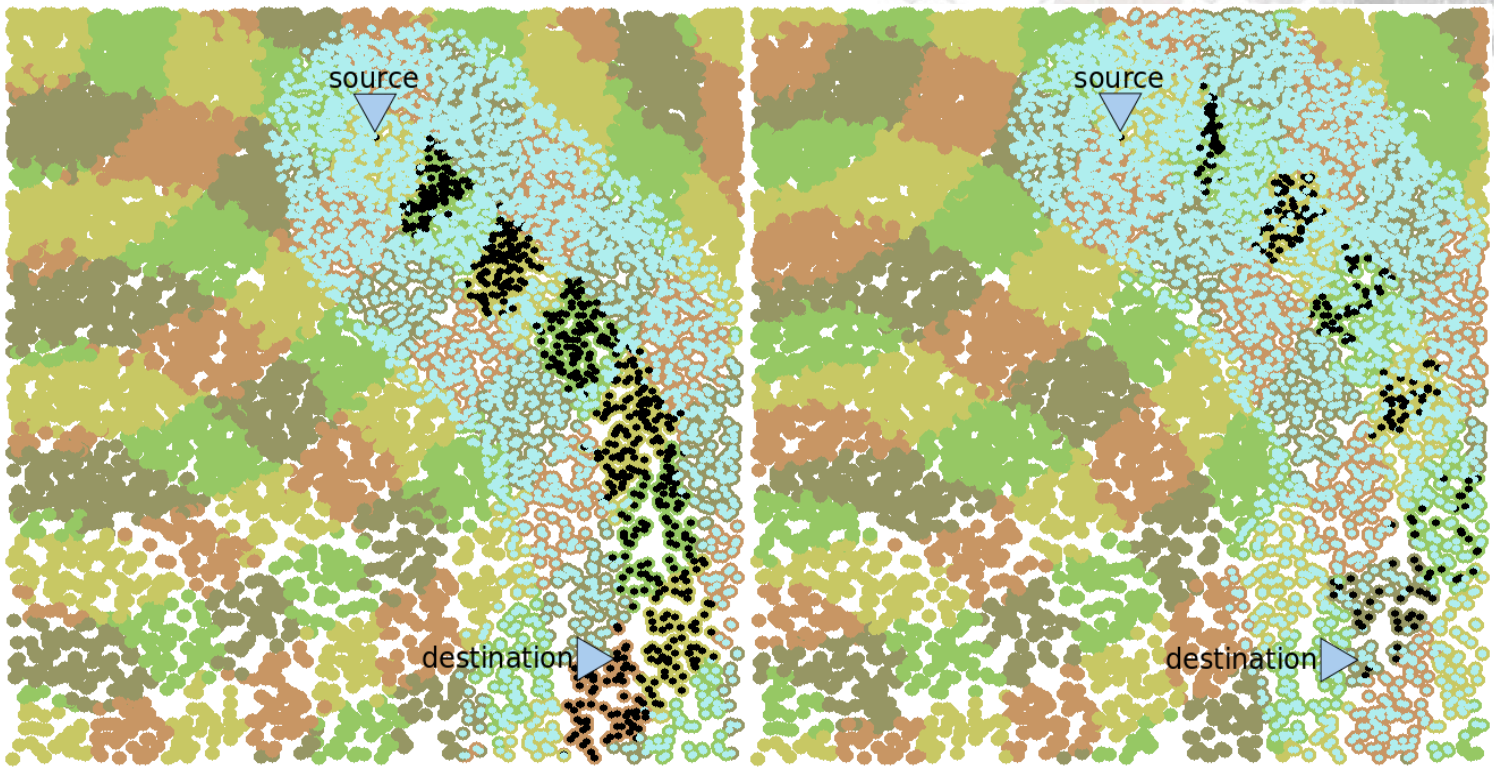
Expanded Ring:



Without ring (left) vs the expanded ring (right).
Fewer forwarders with expanded ring (black) . The whole network receives (blue).

Pure flooding is the basic **broacasting** scheme:
Nodes that receive the data packet for the first time reforward it.

Expanded Ring:



Without ring (left) vs the expanded ring (right).
Fewer forwarders with expanded ring (black) . The destination receives (blue).

SLR (Stateless Linear-path Routing) is an addressing and **unicast** routing scheme.

- Network is divided into zones using a **coordinate** system of **hop counts** from anchors.
- Nodes that are on a line **between the source and the destination** are **forwarders**.

Expanded Ring:

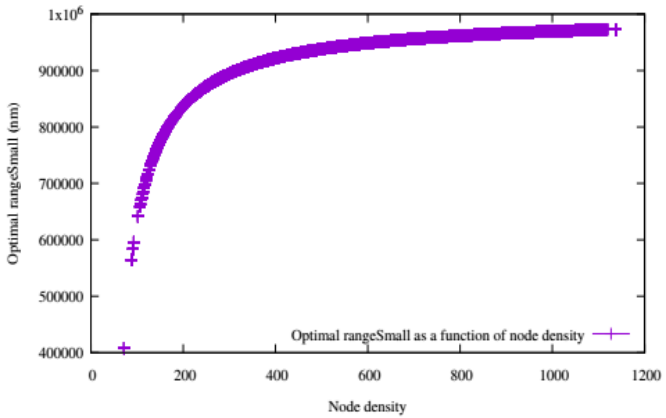
The **expanded ring** improves the routing protocols over many hops: **fewer and better positioned forwarders, succesful packet delivery**.

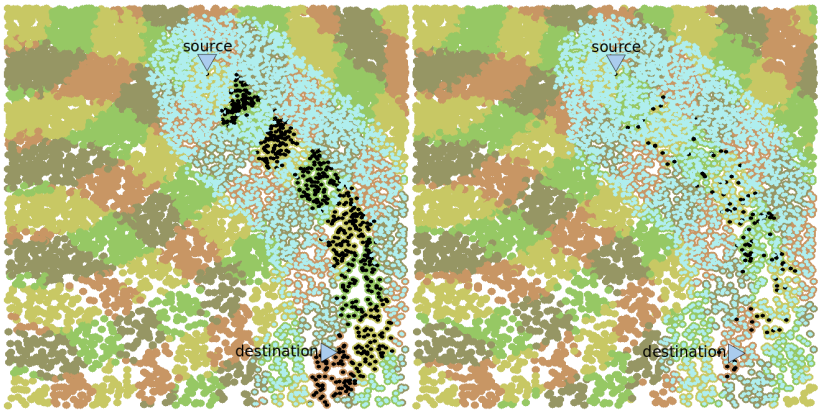
Routing protocol	Reduction with original ring	Reduction with expanded ring
Pure flooding	59.5%	88.8%
SLR	41.9%	86%

Conclusion

- We presented the **expanded ring-based forwarder selection** in a multi-hop transmission to improve packet delivery in **ultra-dense** networks.
- The expanded ring **scales up** routing protocols and achieves high network performance.

Since the submission, we have improved the ring and made it **dynamically** select its width according to node density.





I had the pleasure to present you our work.
Thank you