



N3Cat

Nanonetworking Center
in Catalunya



Discrete REsource Constrained neTworking: “DIRECT”

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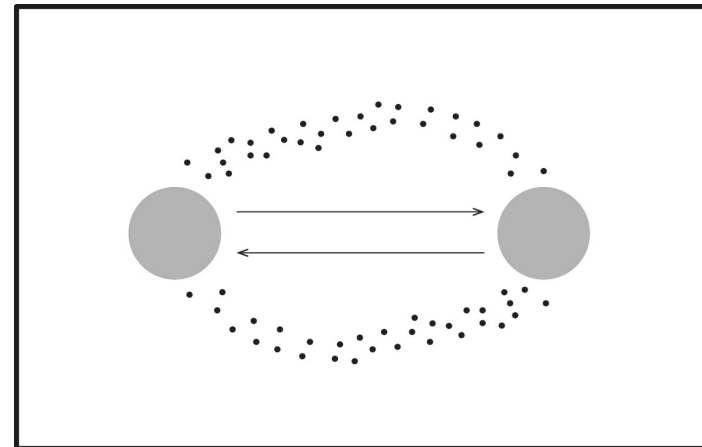
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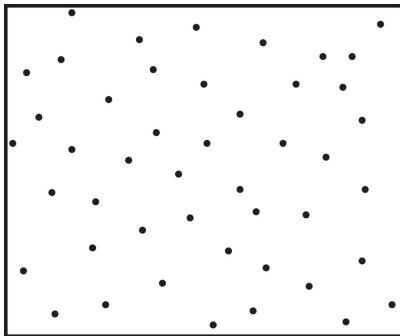
- There exist an infinite recirculation of resources in molecular communication.
 - ions, hormones, small molecules
 - discrete, physical entities

- DIRECT's prime intention is to model resource recirculation.



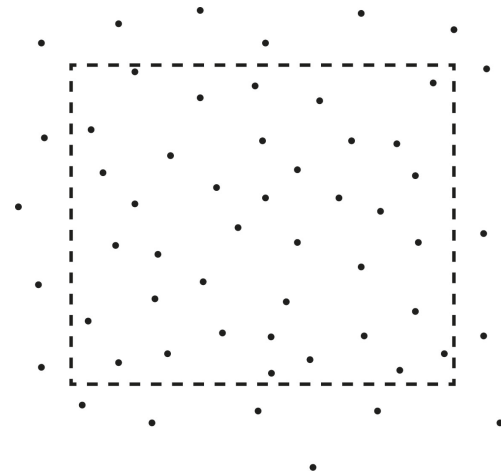
Confined Space

- Reflective boundaries
- Constant amount of resources every time



Unconfined Space

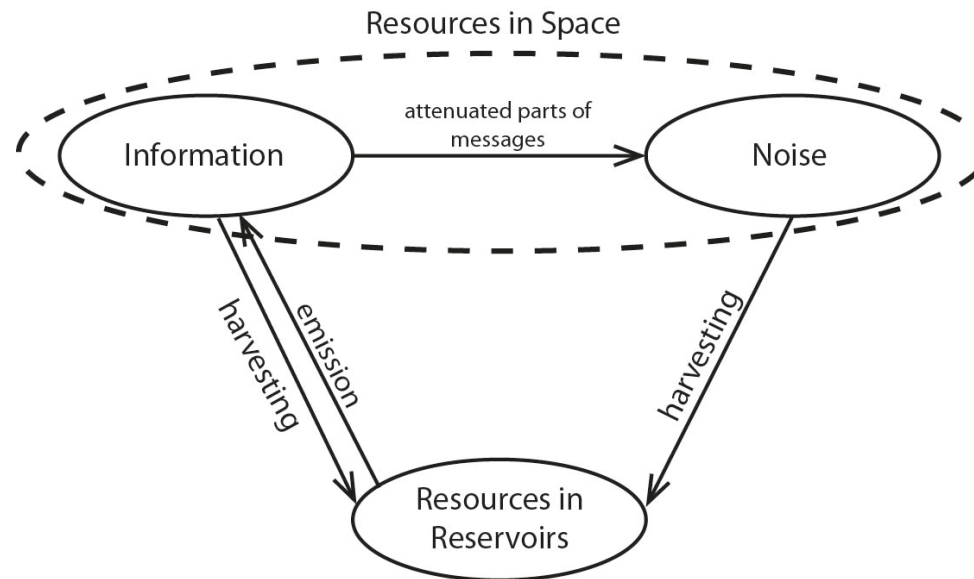
- Open boundaries
- Resources disperse over time



- Any kind of discrete physical entity which is required by a task within network.
 - ▣ Perpetuality
 - ▣ Reusability

- Every node operating in network:
 - ▣ has an internal reservoir.
 - ▣ harvests resources and keep in reservoirs for future use.

- Information and noise in internode space is a resource supply for nodes.
 - Duality between information and resources
 - Duality between noise and resources



- Lifespan can be infinite in a confined space if:
 - there is enough resources to “feed” nodes.
 - optimum amount of nodes are deployed.
 - proper harvesting applied

- What is the capacity of the network?
 - Max. number of nodes which can be supported for a given amount of resources in infinite lifespan.
 - For a given number of nodes, how can we find the optimum amount of resources?

- What are the optimum parameters which provide infinite lifespan?

- How can we track resource fluctuations over time with taking into account the reflections from boundaries?

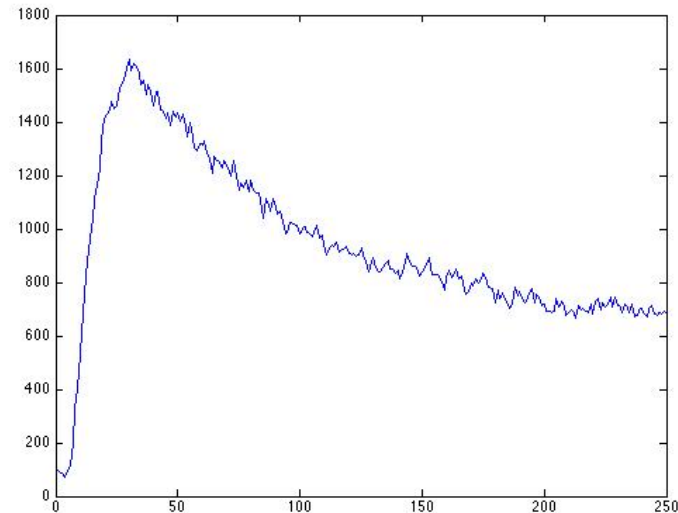
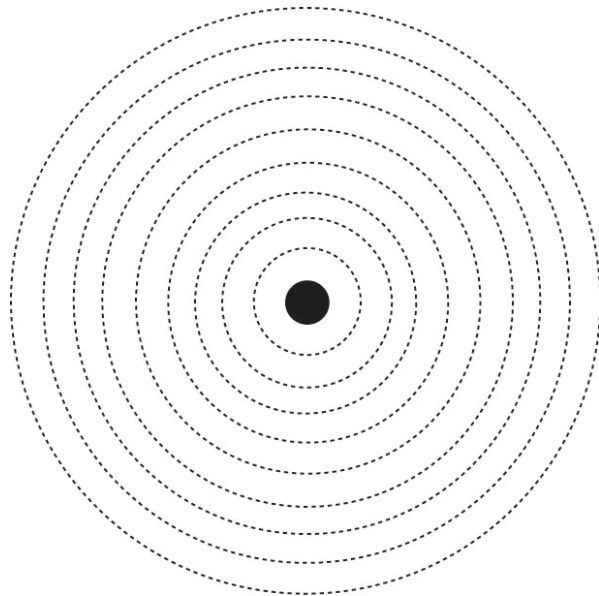
Llatser, I., Alarcón, E. and Pierobon, M., “Diffusion-based Channel Characterization in Molecular Nanonetworks” in Proc. of the 1st IEEE International Workshop on Molecular and Nano Scale Communication (MoNaCom), held in conjunction with IEEE INFOCOM, Shanghai (China), April 2011.

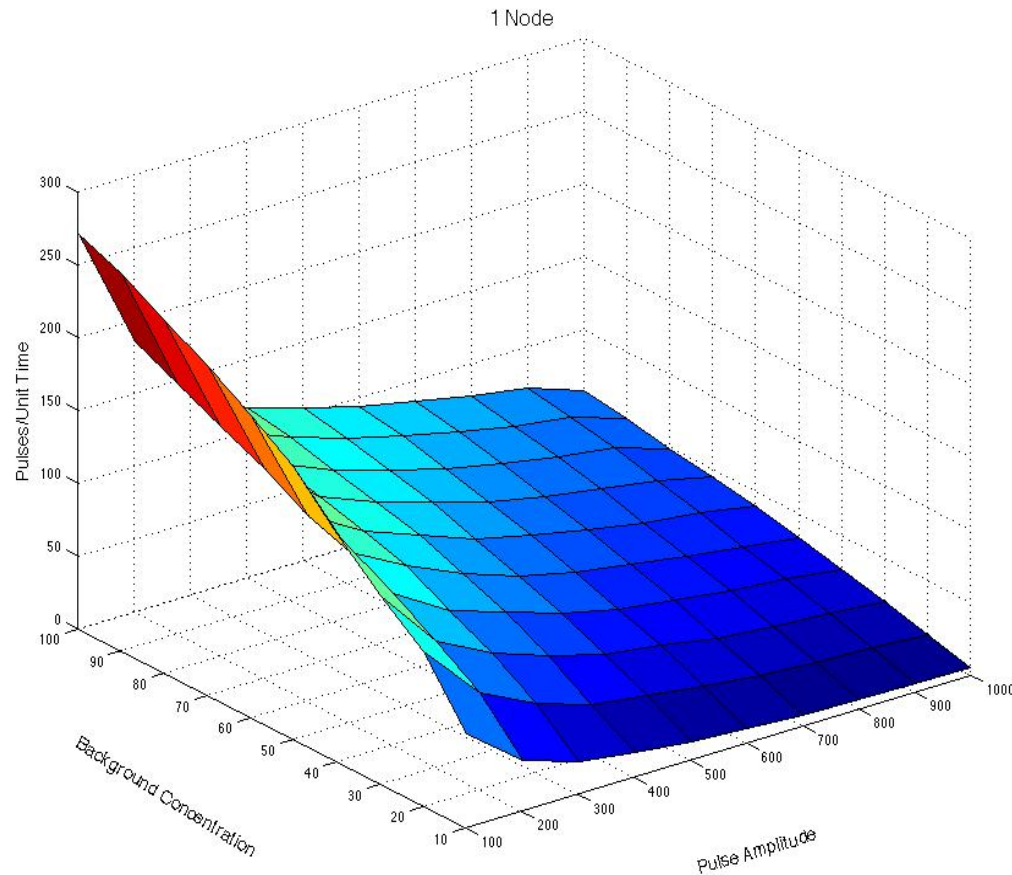
- To represent 1 bit of information:
 - Sender must instantaneously emit a pulse, which includes Q resources

$$C(r, t) = \frac{Q}{4\pi Dt} e^{-r^2/4Dt}$$

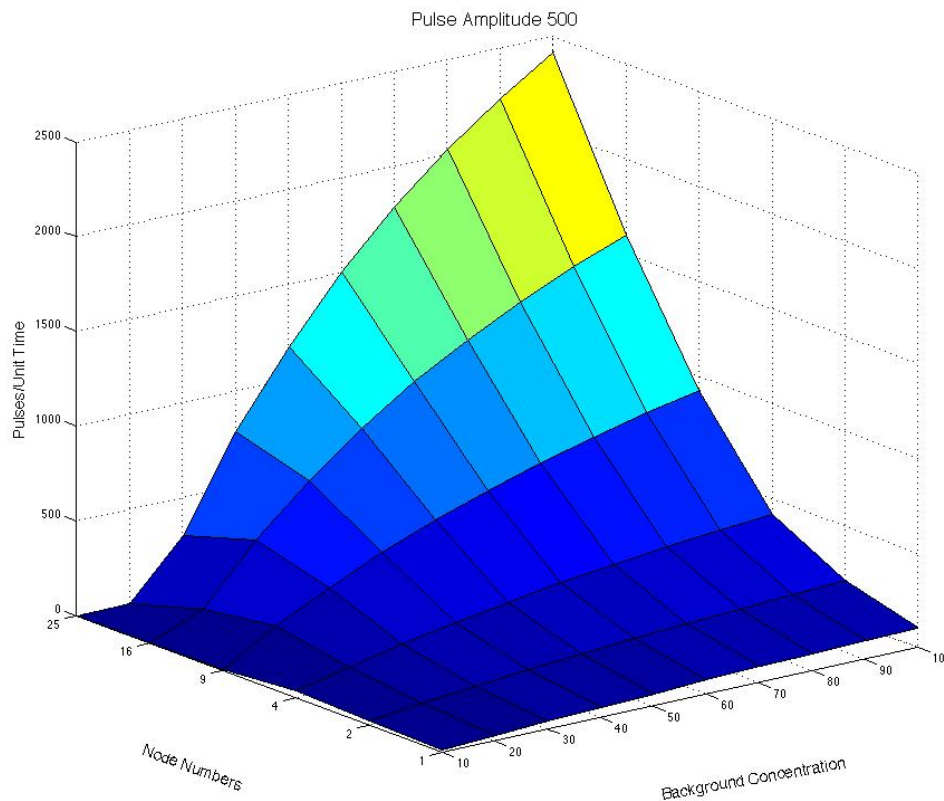
- To emit a pulse, node must harvest enough resources from confined space.

- Emitted pulse will diffuse over space, like ripples in water, eventually reaching the receiver location.



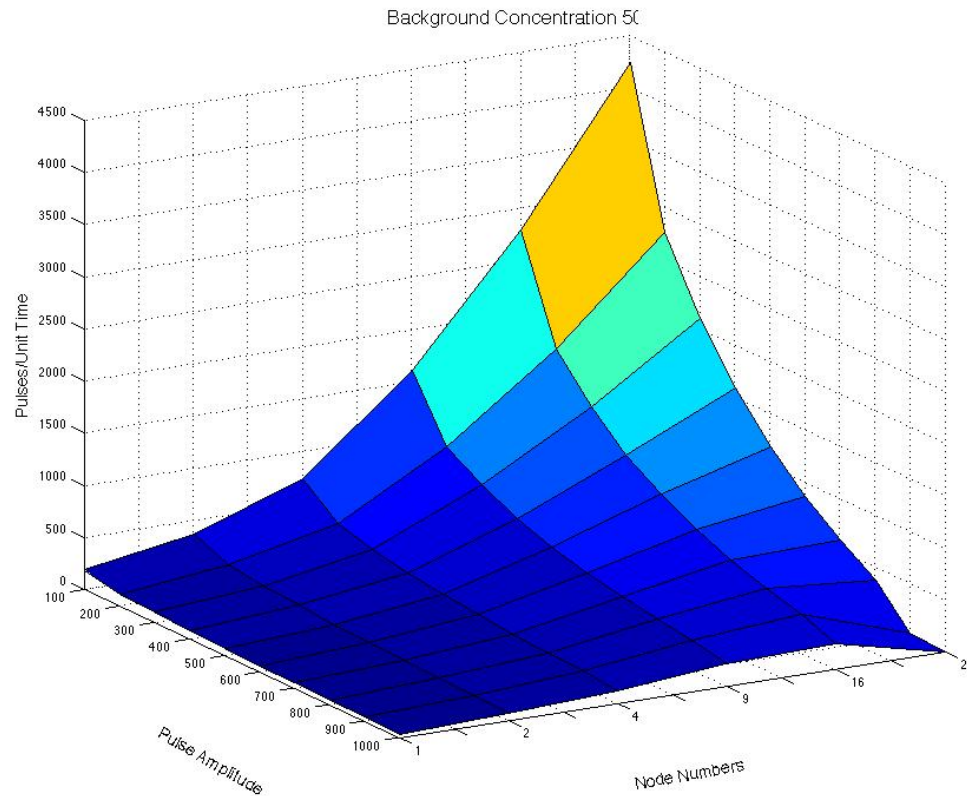


- High pulse amplitudes:
 - Requires more resources
 - Requires more time for harvesting
- To have high pulse/time:
 - High resource concentration
 - Low pulse amplitude

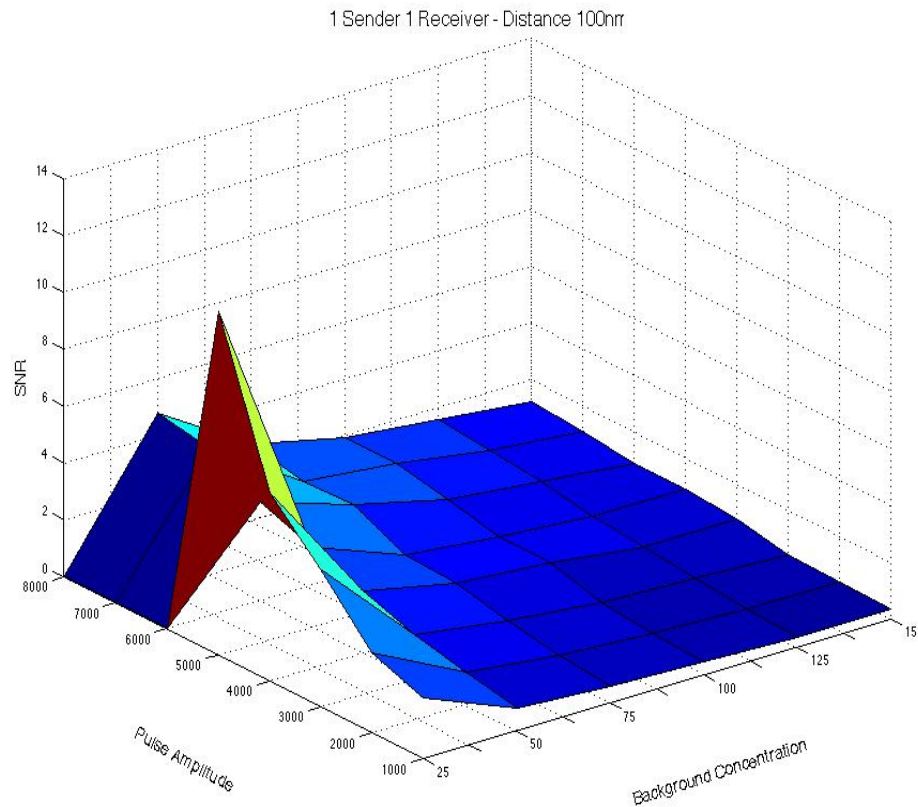


- Homogeneously spread nodes, concurrently harvest resources from different regions of space.
- To operate more nodes, we need more resources
- For a fixed amount of resources, space cannot “feed” unlimited number of nodes.

Pulse Amplitude vs. Nodes

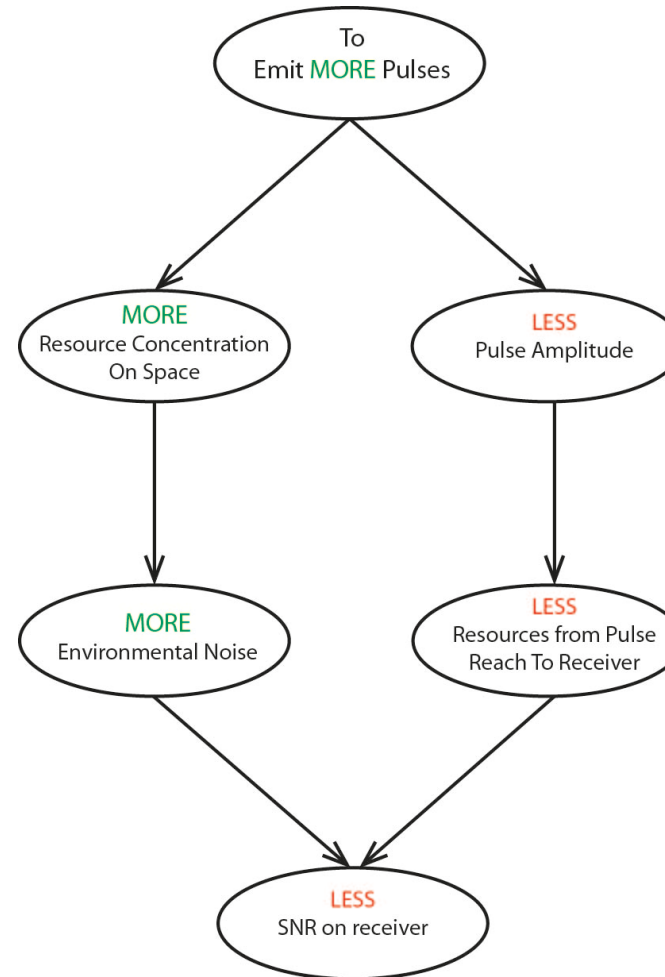


- High pulse amplitude requires more resources.
- Concurrently harvesting nodes releases more pulses.
- Again, space cannot “feed” unlimited number of nodes.



- More resources:
 - can “feed” high pulse amplitudes
 - but increases noise
- High pulse amplitudes:
 - decreases noise
 - increases signal strength
 - but requires longer harvesting time
- High pulse amplitudes and low resource concentrations brings higher SNR at receiver.
- Space cannot “feed” high pulse amplitudes with low resources.

- There is a tradeoff between pulse/time and SNR.



- Fully reusable resources can give DIRECT an infinite lifespan.
- Network may temporarily be unoperational during harvesting.
- Resource recirculation is broken if:
 - Space is unconfined.
 - Excessive number of nodes deployed.
 - Not enough resources to support high pulse amplitudes and/or high number of nodes.

- There is a duality between resources and information...
 - More resource can be used to encode more information as messages.
 - More messages brings more resources in space.
- There is a duality between resources and noise...
 - More resource means more noise.
 - And more noise means more resource.

Questions?..



- This work is supported by The Scientific and Technological Research Council of Turkey, “TUBITAK”