



Research Consortium in Speckled Computing

SpeckZones and Optical Communication

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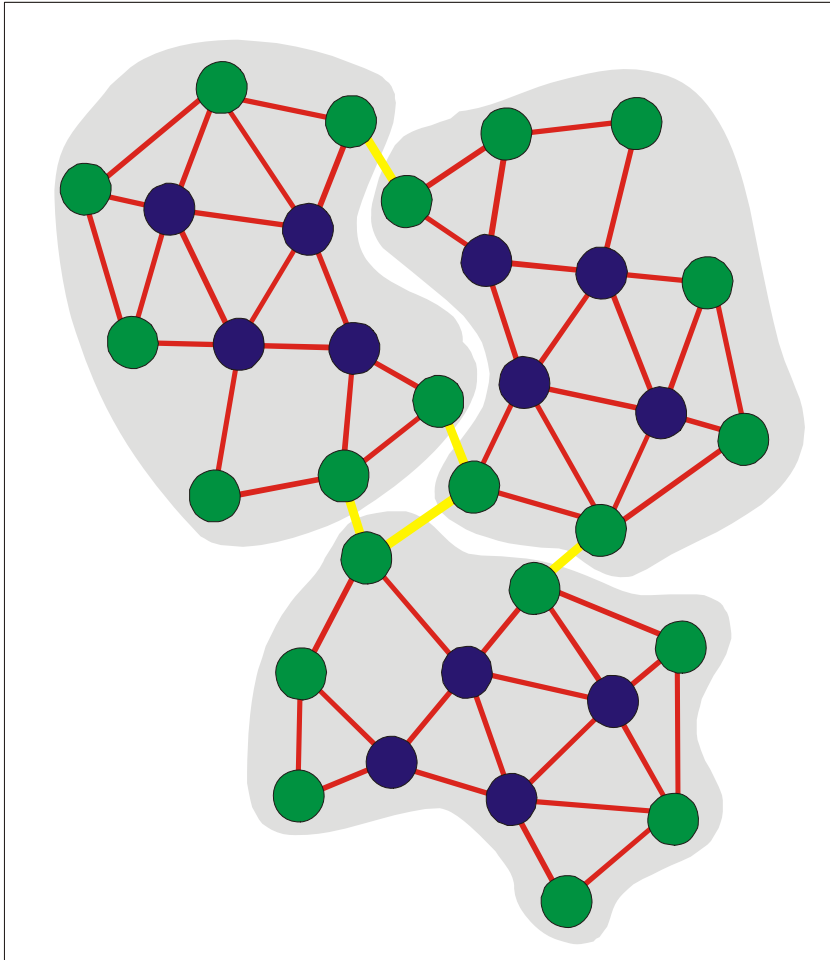
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 - Description of model
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- Uses for lasers in the speckZone system
 - Intra/inter zone communication
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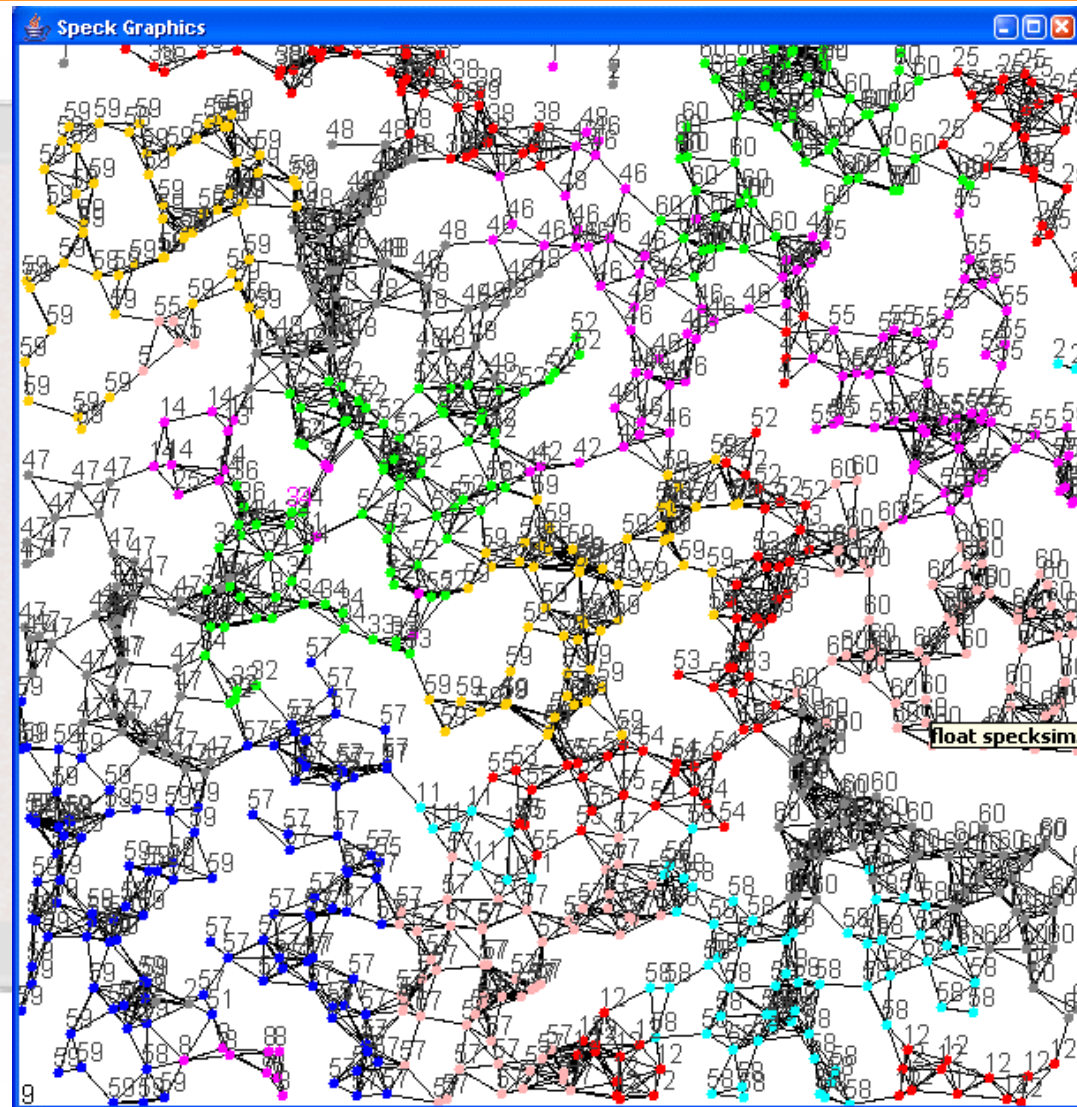
SpeckZone Overview



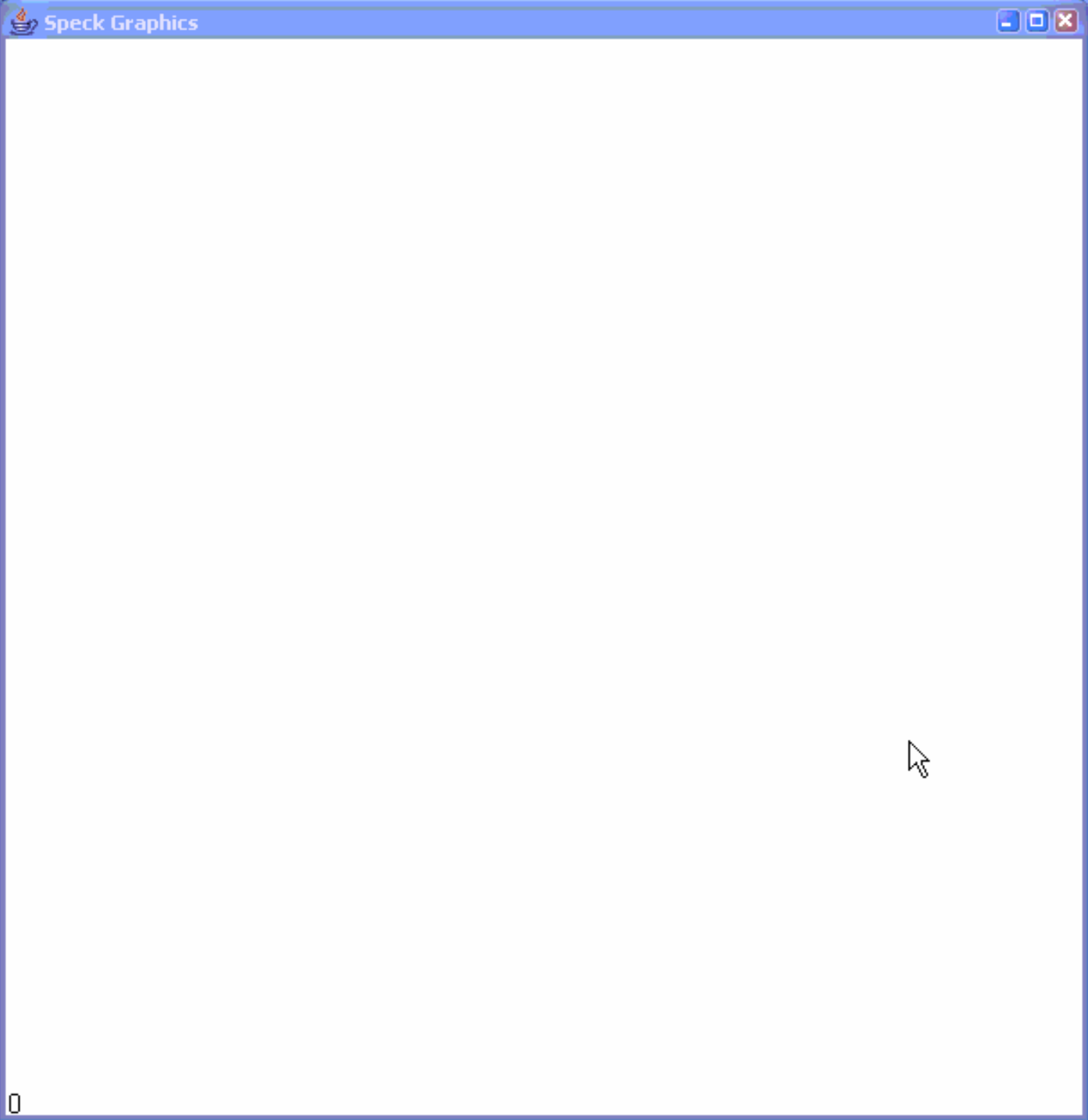
- Individual specks are lightweight and unreliable.
- Group specks into speckZones of roughly equal size.
- Allows specks in each zone to share resources.
- Programs can now run on zones rather than individual specks.

SpeckZone Overview

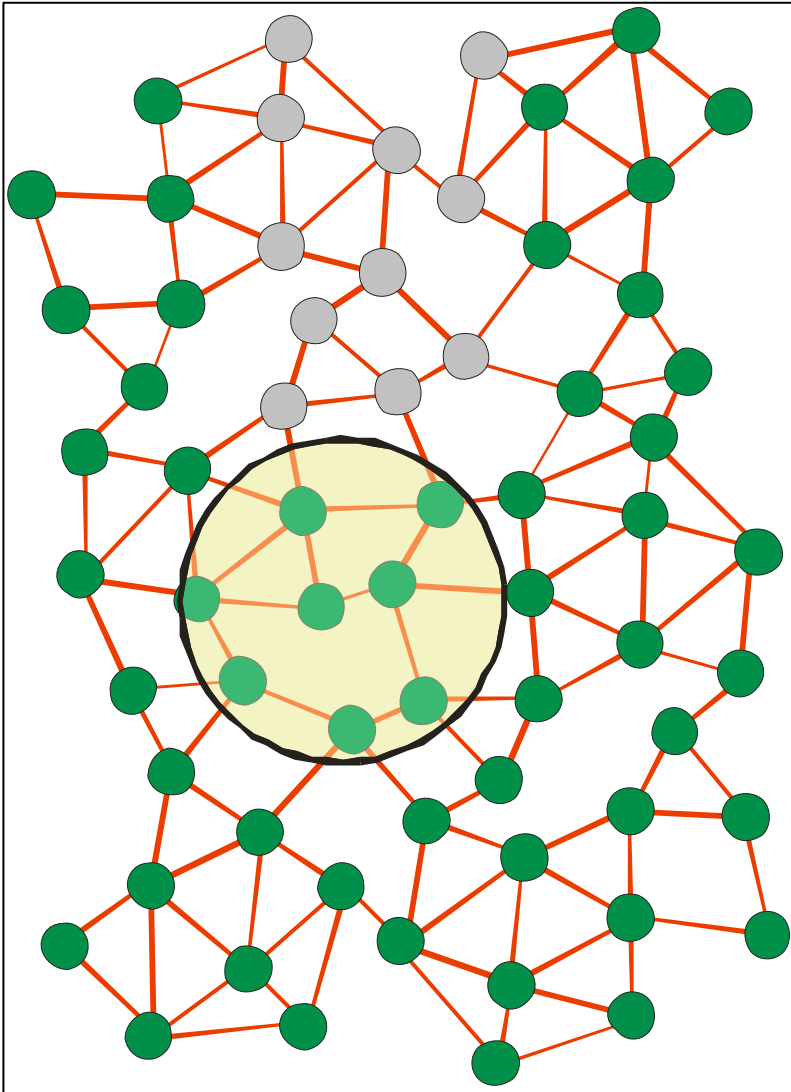
- SpeckZones are formed and maintained by a decentralised, leaderless algorithm.
- Groups of specks of the same colour indicate a zone.
- This example requires a zone size of 40-60.



Video



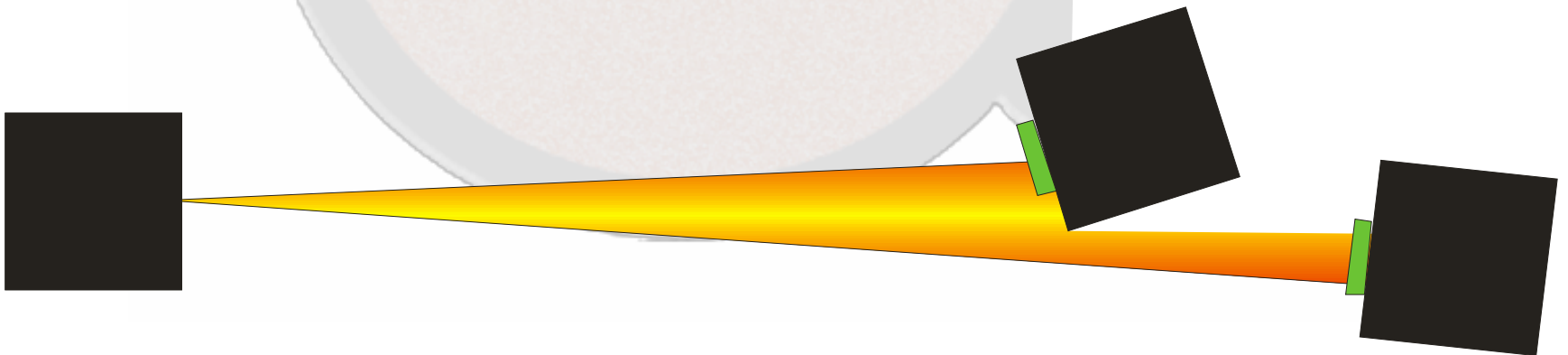
Power Aware speckZones



- The life of a specknet can be increased by only using a small part of it at a time.
- A speckZone moves across the network, using resources as it travels and leaving a trail of exhausted specks.
- Specks that are not in the zone are in a sleep state but need to be woken remotely when required.

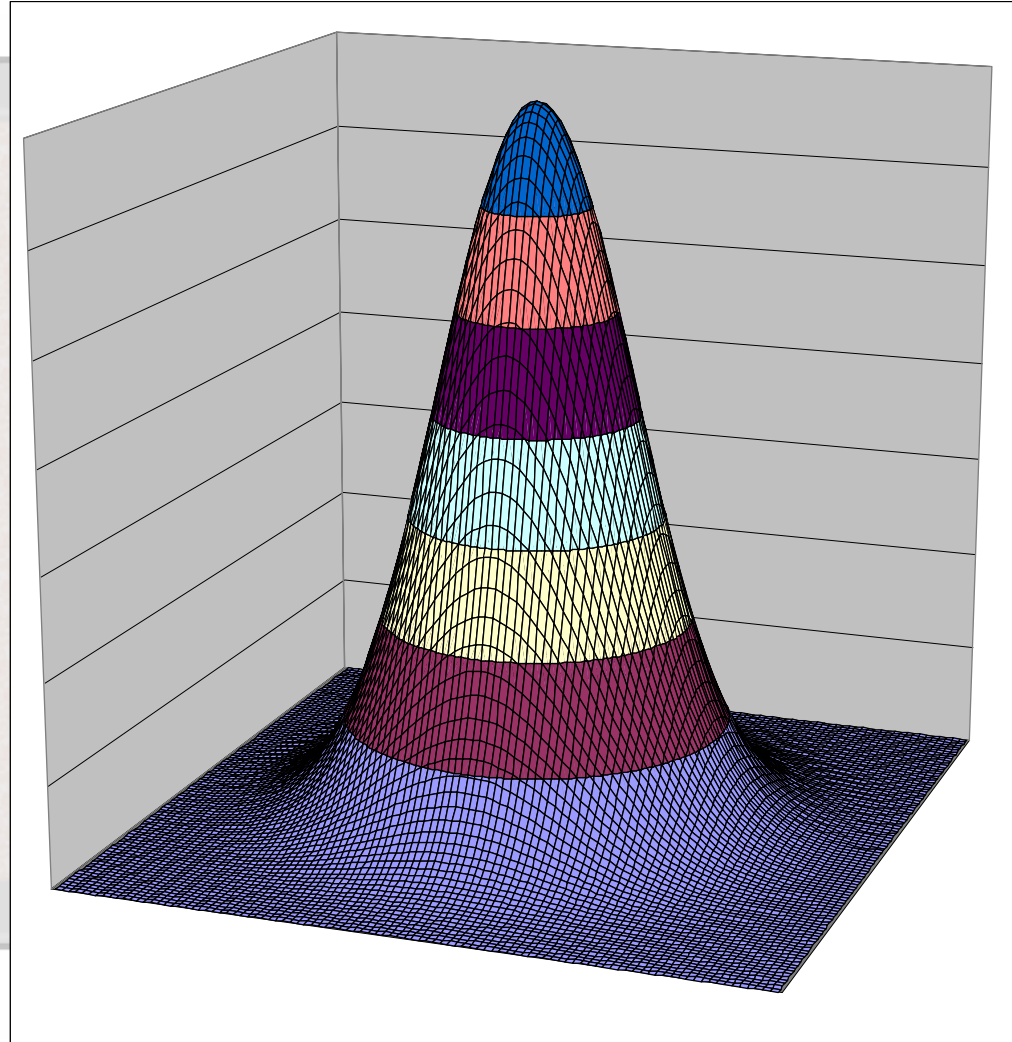
Laser model

- An accurate 3D laser model was produced to see how lasers could be used for communication/wakeup within the speckZone system.
- Multiple lasers and receivers on each speck.
- The beam is divergent and steerable. The power distribution across the beam is modelled as a Gaussian.
- Occlusion of part or all of the beam is calculated.



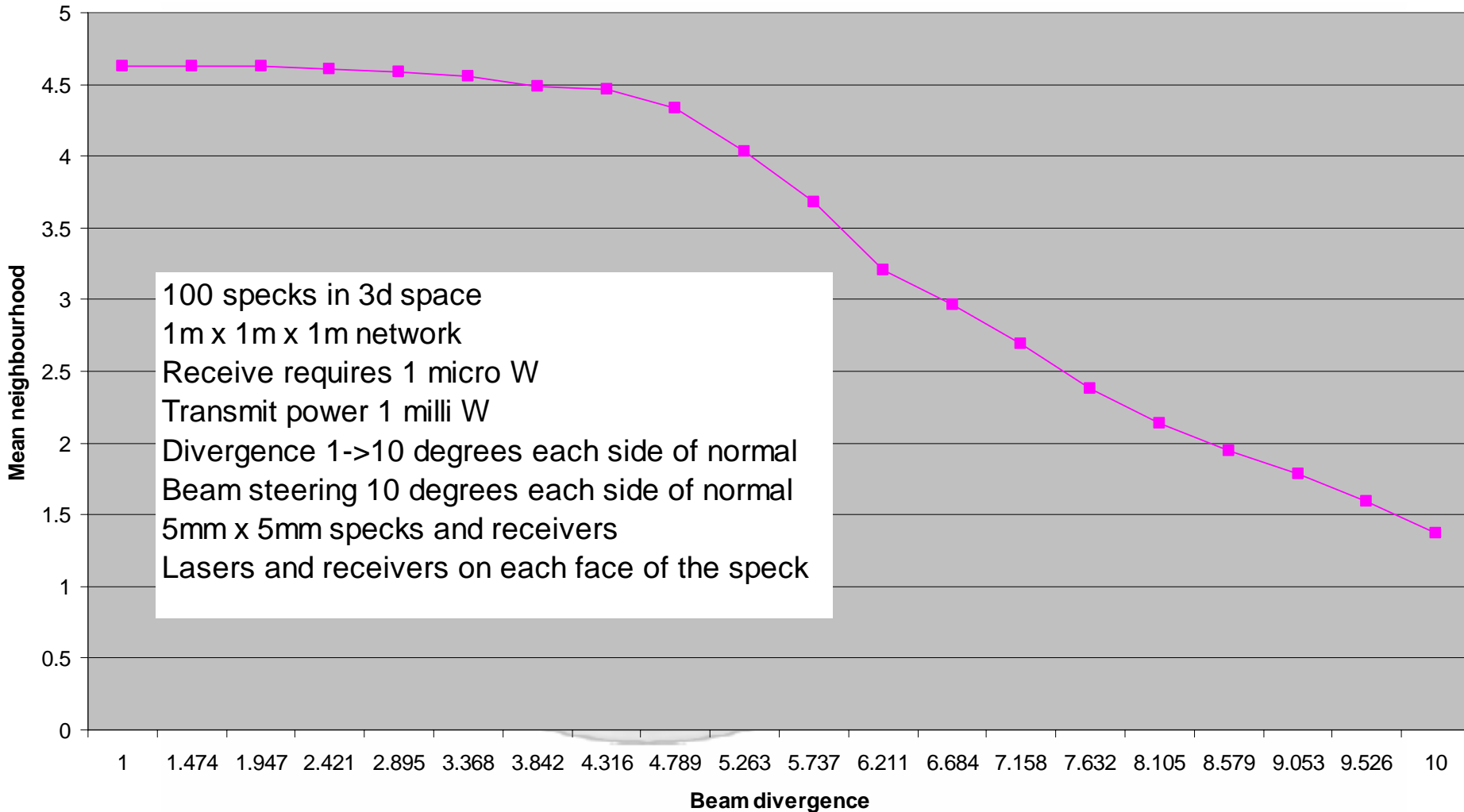
Laser Model

- The actual power of the laser light hitting a detector is calculated.
- The size and shape of the receiver is modelled.
- The incoming angle of the beam and any offset due to steering errors is taken into account.



Results

Beam divergence and Neighbourhood size (1m x 1m x 1m network)

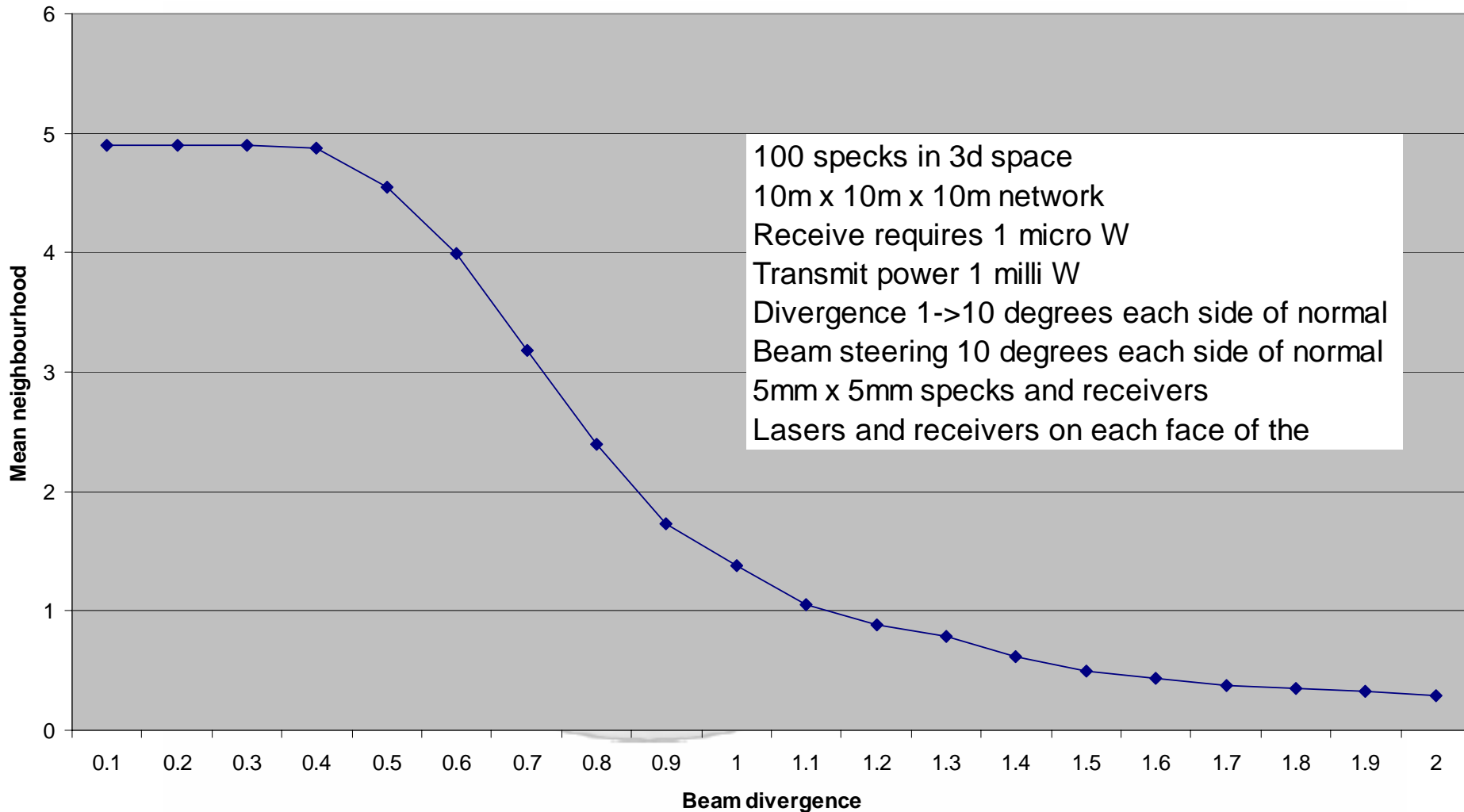


Communicating large distances with 1mW

- Output power fixed at 1mW due to safety standards.
- Received power can only be increased by:
 - Increasing the size of the receiver (and the speck)
 - Reducing the divergence of the beam.
 - We will need fractions of a degree for 1 microW to be received tens of metres away.
 - As the divergence is reduced, steering accuracy and DAC resolution become critical.

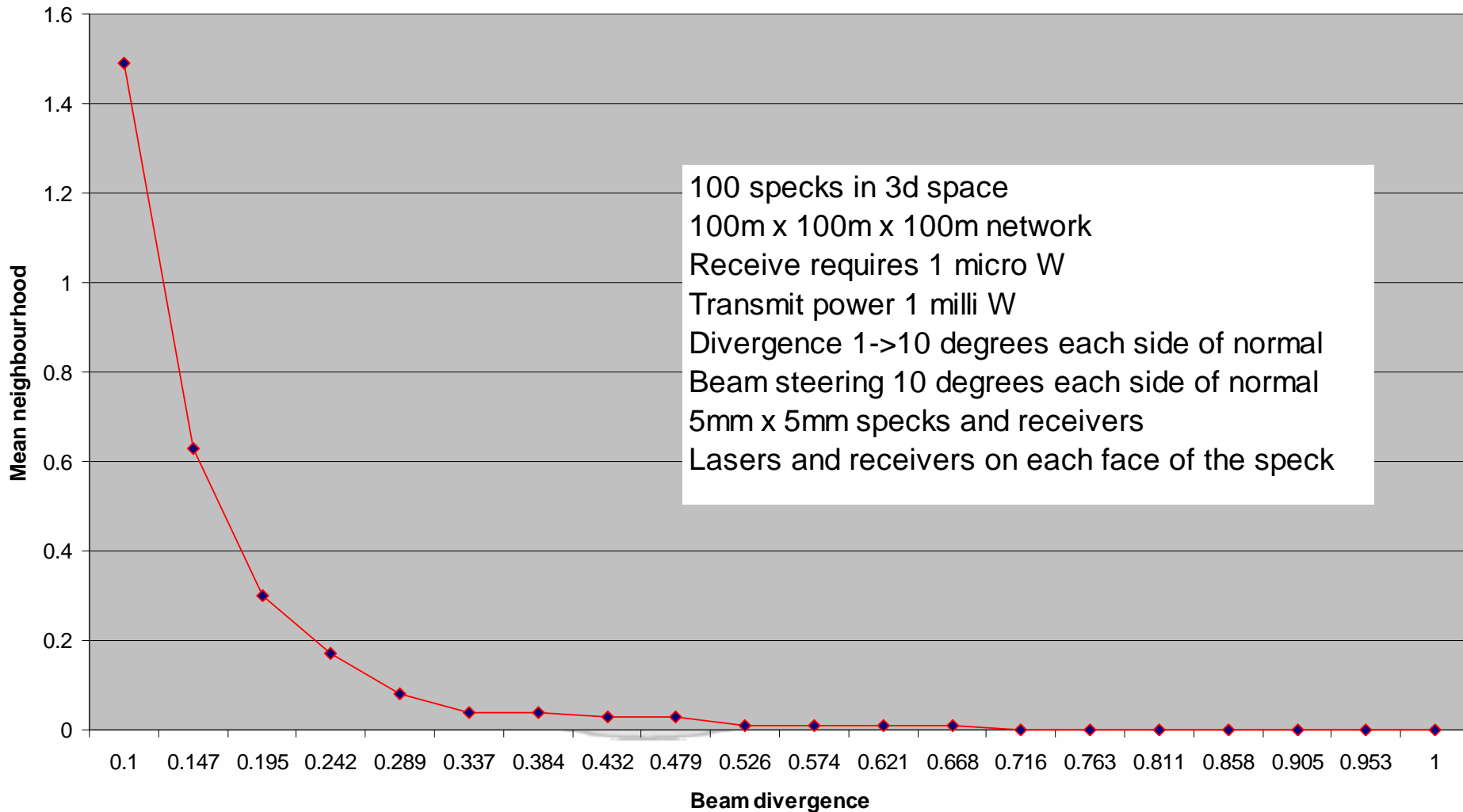
Results

Beam divergence and neighbourhood size (10m x 10m x 10m network)



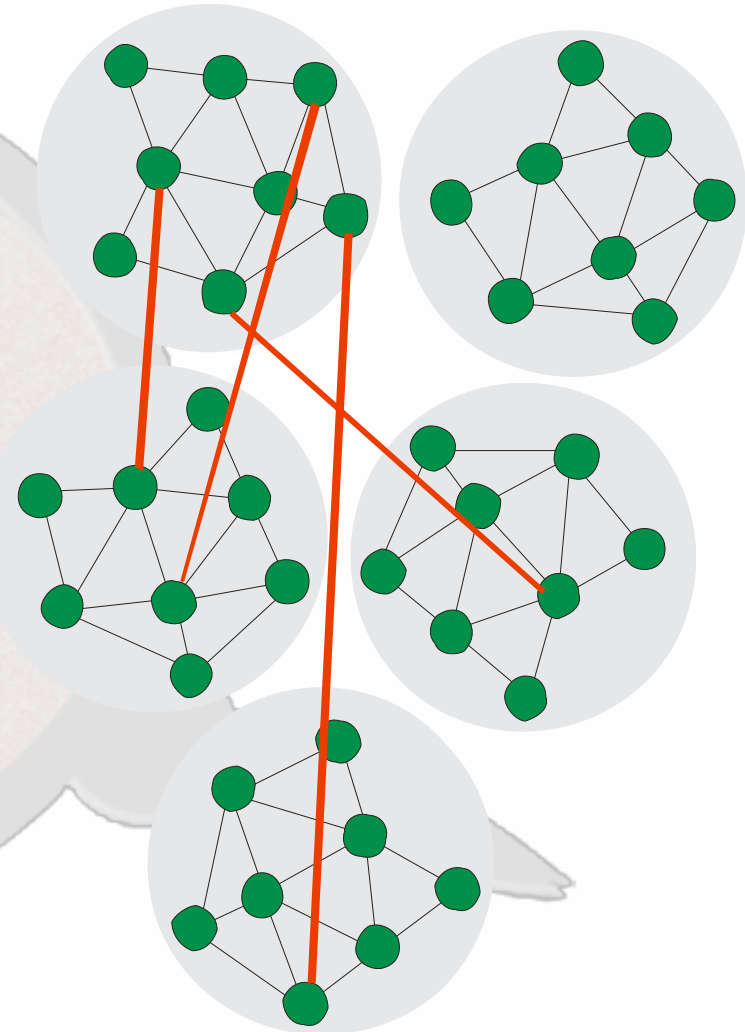
Results

Beam divergence and neighbourhood size (100m x 100m x 100m network)



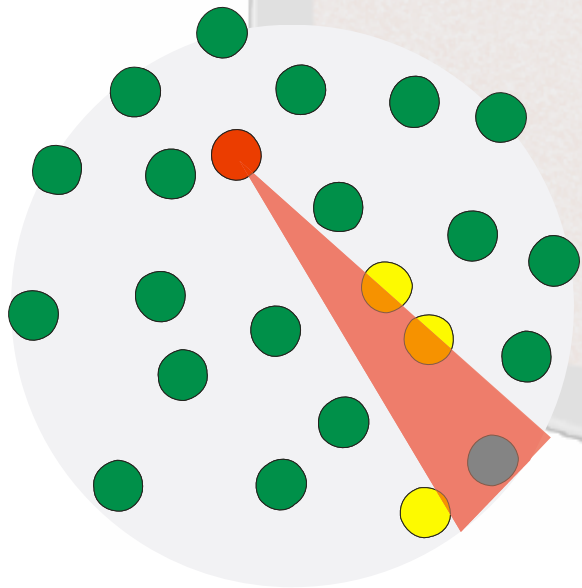
Uses for the laser

- When using multiple steerable lasers and a detector on each face of the speck, communication with some zone members is highly likely.
- Communicating over more than a few meters is problematic due to received power and alignment issues.
 - Communication between nearby speckZones is still likely.



Advantages of laser communication

- What do lasers offer over radio?
 - Directionality – less channel congestion.
 - Low power incoming beam detection when sleeping.
 - The red speck transmits to the blue speck.
 - When using radio, 21 additional specks receive the message.
 - When using laser, there are just 3 unwanted receptions (14% of the zone).



Remote Wakeup

- Specks need to sleep when not being used, but must it must be possible to wake a sleeping speck wirelessly.
- Remote wakeup using radio requires that much of the receiver circuitry is active.
- Optical communication requires only an ultra low power wakeup detector, that can turn on the main receiver circuitry if an incoming beam is detected.
- If solar cells are used as laser detectors, they can also generate power to run the wakeup detector.

Initial experiments

- Wakeup experiments were conducted with the following:
 - 3V 1mW laser
 - 5mm x 5mm solar cell
 - Function generator connected to transistor to drive the laser at a given frequency.
 - Solar cell connected to oscilloscope to detect the same frequency in the output from the solar cell.
 - Laser aligned with solar cell a few cm away.

Results

- Laser and solar cell are difficult to align manually.
- Pulse frequency of 5KHz is clearly visible on the scope.
 - Increasing the frequency beyond about 7KHz doesn't work.
 - Reducing the frequency below about 3KHz doesn't work.
 - This may be due to the laser, transistor or solar cell.