National Aeronautics and
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Mesh Network Architecture for Enabling Inter-Spacecraft Communication

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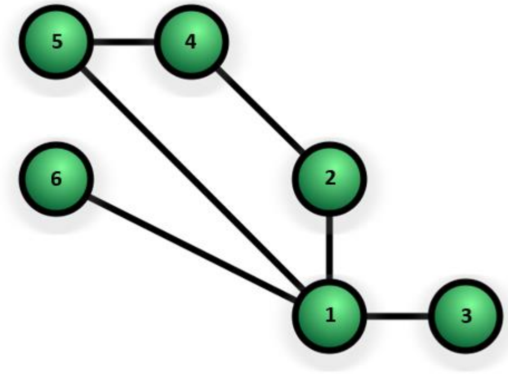
Overview and Design Goals

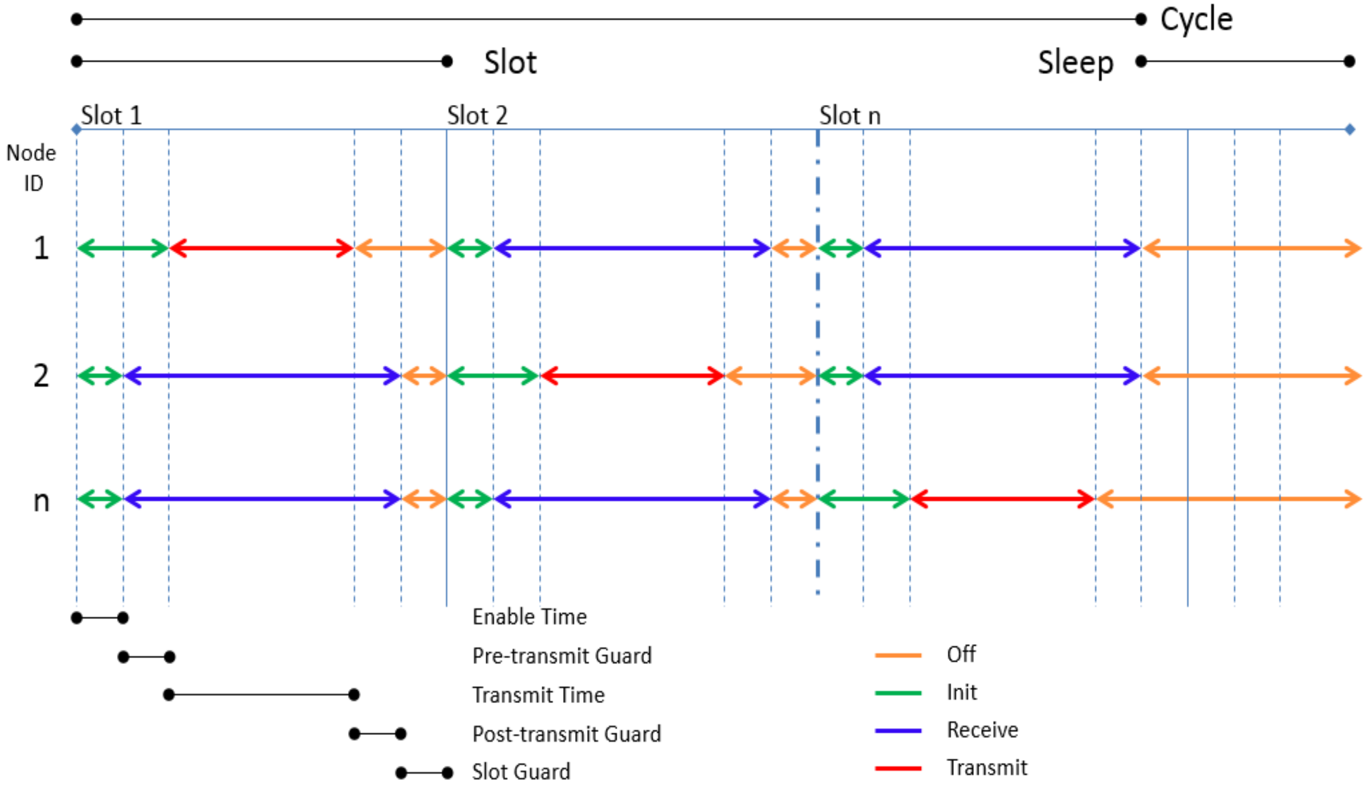
- Primary Goal: Implement a mesh network communication architecture to enable spacecraft collaboration and reduce ground communication requirements.

- Driving design requirements:
    - Peer-to-peer network design without a master control node.
    - Adaptability and re-configurability.
    - Data relay.
    - Hardware independence.



Network Architecture

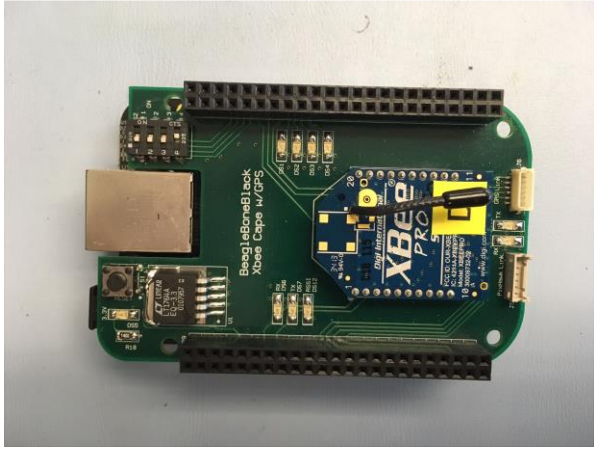
- Network is based on a Time Division Multiple Access (TDMA) scheme.
- Each network node has an assigned broadcast slot during which it can send data and the other network assets will receive.
- Network parameters are configurable to allow for adapting the network for different applications.



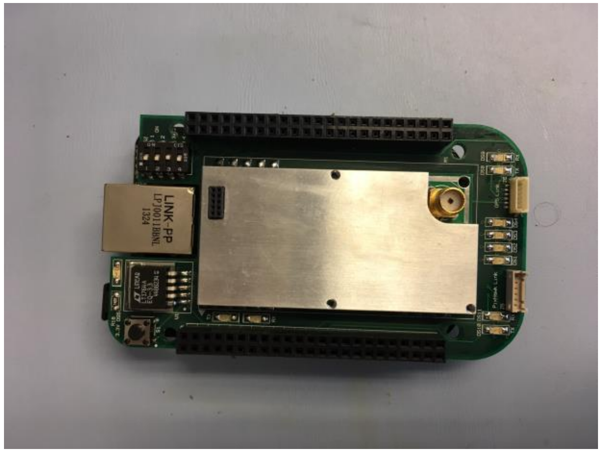
Software/Hardware

- Initial software development was performed in Python.
- Network logic was ported to VHDL for the current generation which uses an FPGA to further refine networking timing.
- C++ implementation also available.
- The BeagleBone Black single-board computer was chosen as a flight computer analog for rapid hardware evolution and testing.

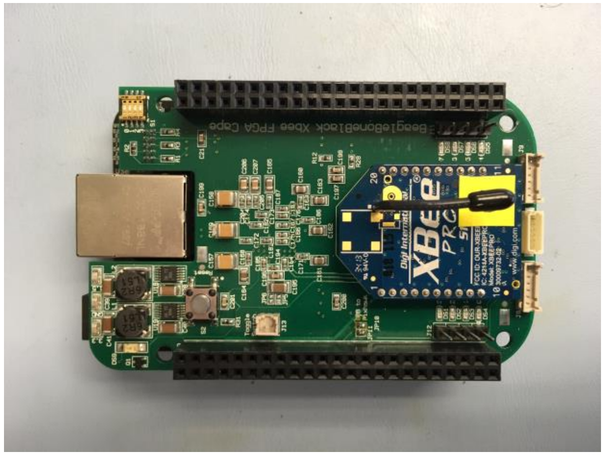
2nd generation XBee node



2nd generation AstroDev node



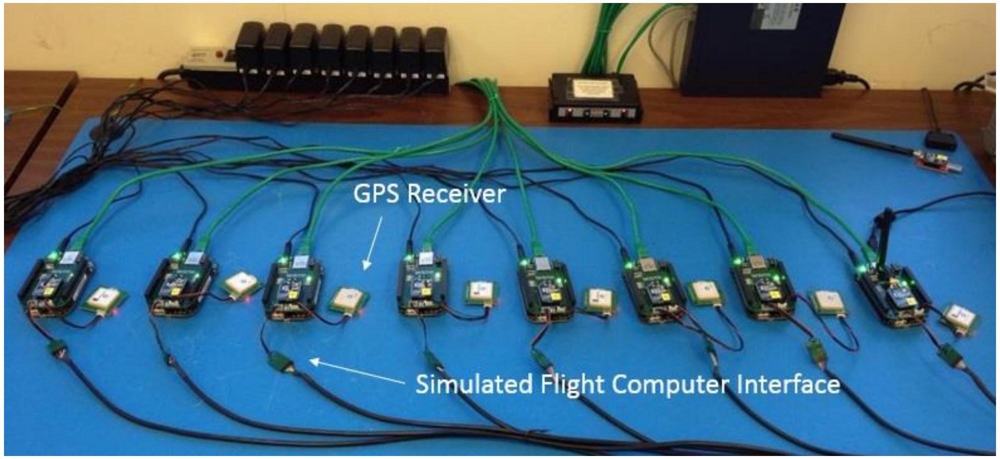
3rd generation FPGA node



Testing

- To stress test and prove out the network control, small unmanned aerial vehicles were used as a flight test platform.

- A spacecraft deployment scenario was tested via simulation.



Video

F - Fence, H - Horizontal Move, V - Vertical Move
W - Wait, P - In Position

Node 1 ● FHVWP
Lateral Error (m): 50.9 Altitude Error (m): -19.8

Node 2 ○ FHVWP
Lateral Error (m): --- Altitude Error (m): ---

Node 3 ● FHVWP
Lateral Error (m): 49.5 Altitude Error (m): -19.9

Node 4 ● FHVWP
Lateral Error (m): 41.9 Altitude Error (m): -20.0

Node 5 ● FHVWP
Lateral Error (m): 15.0 Altitude Error (m): -19.9

Node 6 ● FHVWP
Lateral Error (m): 14.5 Altitude Error (m): -20.0

https://www.youtube.com/watch?v=oH9C43To3Dk

Conclusion

- A peer-to-peer, master-free mesh network was developed and demonstrated to enable collaboration between spacecraft and reduce reliance on ground communication.
- Future development goals:
  - Implement dynamic, autonomous network reconfiguration to reduce dependence on prior knowledge of the number of network assets.
  - Move to a flight-ready hardware and software implementation to prepare for future flight opportunities.

Software available open-source from the NASA Software Catalog:
https://software.nasa.gov

Or from the NASA Github site:
https://www.github.com/nasa/meshNetwork