SPACEWIRE NETWORK TOPOLOGIES

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Long Paper

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Compared with conventional bus topologies, SpaceWire brings not only orders of magnitude improvement in performance but also huge flexibility in the network topologies that may be used. Topologies can be chosen to maximize performance or fault tolerance, or to minimize power consumption, cost, or harness mass. Often a balance will be struck that optimizes the total mission. This paper points out a range of possible topologies and discusses their relative merits in terms of these parameters.

Perhaps the simplest network to consider is a daisy chain between the different nodes. This might minimize harness mass but, like a bus, it can be cut into two halves that are unable to communicate.

Adding one more connection to a daisy chain creates a ring. This also has low harness mass, but it can be cut anywhere and the result is a daisy chain with everything still connected. Compared with a bus, which can only have a single packet on the network at once, a ring offers what is referred to as “spatial re-use” so that several packets can be in transit at the same time, offering a significant increase in performance.

Another familiar topology is a star or hub, with spokes going from a routing switch (or mux/demux) to the nodes. This can offer significantly higher performance than the ring, but is likely also to have much higher cable mass. A single switch is also a single point-of-failure, and so will tend to be duplicated with a hot or cold spare.

Cable mass can be reduced for a central routing switch by distributing mux/demux devices (or concentrators/de-concentrators) close to a group of nodes, so that each node in the group has a short cable to the mux/demux which then has a single cable to the central routing switch.

More exotic topologies will be touched on, including regular arrays such as grids, toroids, (hyper)cubes and Clos networks. Principles of network diameter (number of hops), degree (number of ports per node or switch) and bisection bandwidth (across a hypothetical plane that cuts the network in half) will be introduced, in engineering rather than mathematical terms.

The paper will conclude with an example synthesis of the concepts covered, optimizing parts of the network for performance, parts for different levels of fault-tolerance and power consumption, and the whole network (within those constraints) for harness length and hence mass.