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Thesis together with TU Braunschweig

Evaluation of Communication Protocols for Satellite Swarms

Motivation:

While classical satellite communication based on satellites in geostationary orbits was used for uploading/downloading data directly, the recent trend of satellite swarms require more and more inter-satellite communication to enable an area wide coverage. A direct integration of satellites to terrestrial 5G networks is intended to provide, e.g., IoEE (Internet of Everything and Everywhere). Ongoing projects are for example OneWeb or SpaceX's Starlink, where OneWeb launched the first bunch of satellites in February 2019. The idea is to put a massive amount of small and inexpensive satellites (800 – 4000) in a LEO (Lower Earth Orbit) which cover the entire surface of the earth while offering high bandwidth and redundant links. However, the low orbit of a LEO satellite
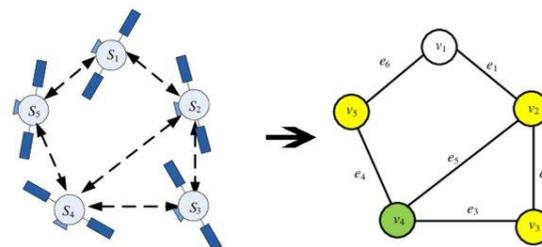

Fig 1:Source: Cooperative Orbital Control of Multiple Satellites via Consensus

leads to high speeds and, thus, to visibility from earth of about 90min only, so that several challenges for inter-satellite communication arise. The movement of satellites is indeed deterministic but routing protocols have to deal with continuously changing node constellations. Furthermore, the capacity of links might change over time, as e.g. the demand of links depends on the area (Europe vs. Pacific area) and time (daytime vs. nighttime). Of course, a low latency as well as high throughput is also desired. Unfortunately, so far only few information about the protocols that should be used for inter-satellite communication (routing or transport protocols) are available. Starlink only provides the information that a peer-to-peer protocol claimed to be "simpler than IPv6" will be used.

However, for a variety of "terrestrial" applications we already have a plethora of protocols that might fit the requirements mentioned above, e.g. from MANET applications. What is missing is a deeper analysis and evaluation how existing protocols perform for such swarm satellites…. and which drawbacks/benefits do exist.

Work description:

You will start with a comprehensive research study to gather information on existing protocols that are used for inter-satellite communication as well as related "terrestrial" communication. To perform an evaluation of potential protocols you should preselect a suitable simulation environment where links between LEO satellite constellations can be simulated. The comparative analysis of the protocols should be documented properly. A discussion on advantages and disadvantages of the different protocols is also required.

Prerequisities:

For successful thesis completion, you should fulfill the following requirements:

- Background in computer networking and communication protocols
- Prior knowledge about network simulation tools (e.g. Omnet++, ns3) is beneficial
- The willingness for hands-on implementation as well as theoretical considerations and analyzes

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