Data Communication for Underwater Sensor Networks

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Introduction and applications

Applications:
- Surveillance and security of sites
- Harbour protection
- Anti-submarine warfare
- Mine countermeasures
- Oceanographic data collection

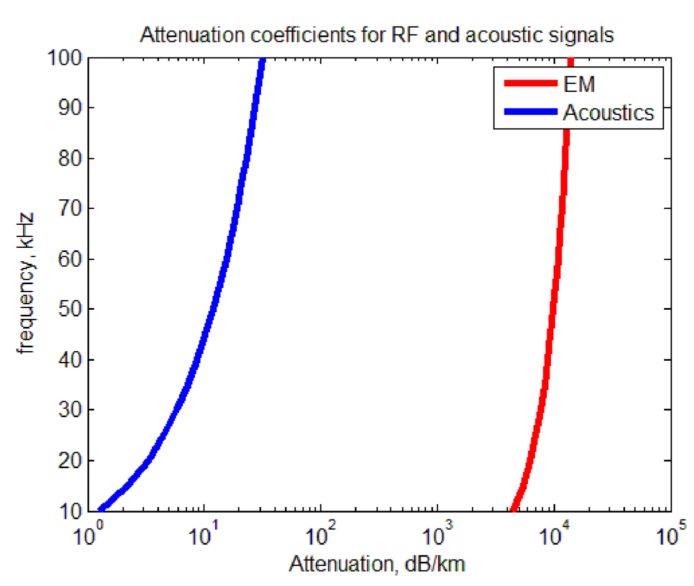
Single sensor	Network
dependent on platform	long operation time
expensive	reduced cost
inflexible	complex environment
limited area	broad area

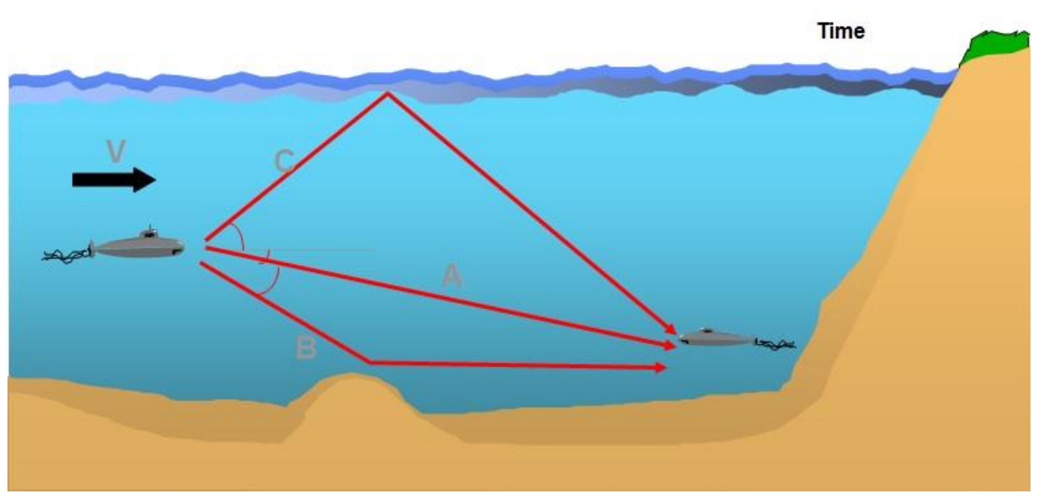
Table: Comparison between using single sensor and a network of sensors for underwater communication

- Networked sensors have the advantage of collaboratively exploring an area of interest. This would be beneficial for underwater applications such as real time surveillance and exploration, which are impractical with the current state of technology using single sensors.
- However, there are some fundamental limits and challenges for enabling a robust and efficient deployment of such networks. One of them is the data transfer between nodes of the network. This project aims to explore novel approaches to improving channel characteristics in underwater communications, with a view to implementing, and testing the measurable underwater performance of the system.

Challenges for Acoustic Communication

- Path loss – mainly due to attenuation . The energy of the signal is scattered or absorbed and converted into heat. Sea water attenuation is prohibitive for EM energy and this dictates the use of acoustic signals for underwater wireless communication.



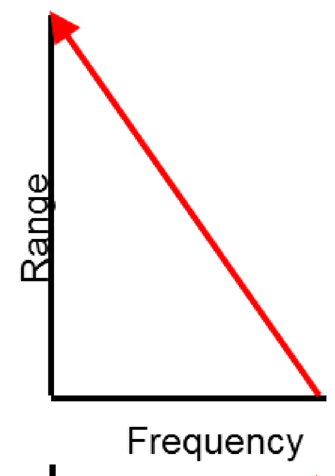


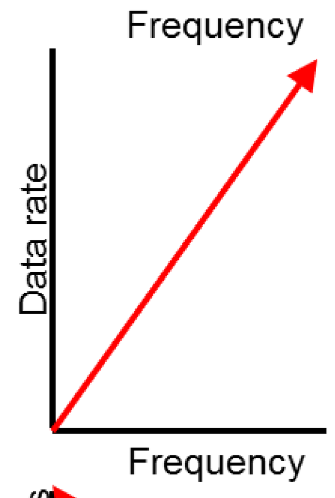
- Multipath – due to multiple reflections from the sea bed or the surface; leads to intersymbol interference in the receiver end.

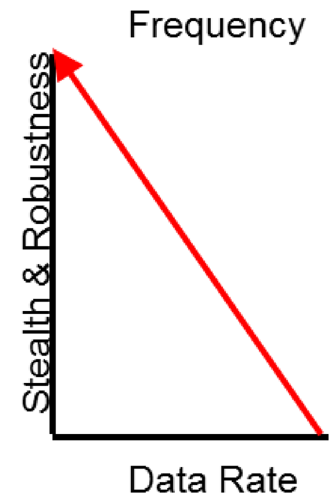
- Doppler spread – the variation of Doppler shift in different parts of a signal; most significant contribution to Doppler spread is rough sea surface caused by wind.
- Noise – man-made, such as machinery noise and shipping activity; ambient noise caused by hydrodynamics.
- Large propagation and time-varying delay – the high delay is due to the propagation speed of sound underwater. Typically, it is around 1500 m/s, which is 5 orders lower than in radio channel. Its variation over time leads to problems in protocol design.

Problem

- The main physical constraint is the limited available bandwidth. Due to the harsh environment, the underwater acoustic data transfer is severely reduced, compared to terrestrial communication.
- The trade-off between range and data capacity limits the choice of frequency. For high data rate, the nodes in a network need to be in very close proximity.
- Bandwidth is affected by path loss, Doppler spread, multipath, ambient and man made noise, large propagation and time-varying delay







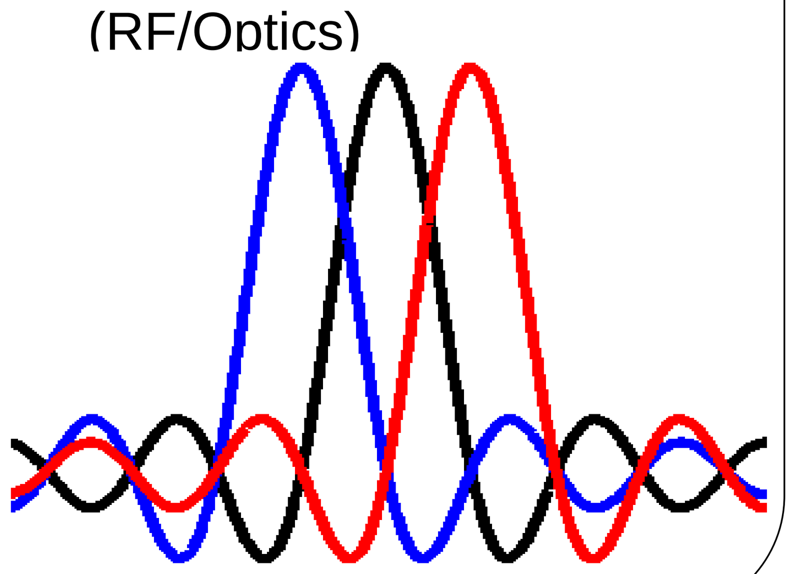
Span	Range (km)	Data rate
Short range	<1	~ 20 kbps
Medium range	1-10	~ 10 kbps
Long range	10-100	~ 1 kbps
Basin scale	3000	~ 10 bps

Table: Data rate for underwater acoustic wireless channels

Solutions

In order make the underwater acoustic communication robust, efficient and reliable, there is the urge to recognise similar problems in other domains. The technology used there might be applicable for the challenging underwater environment as well. This project is focused on researching solutions applied to terrestrial wireless networks and deep space communications.

- Modulations
- Orthogonal Frequency Division Multiplexing
- Multiple Input Multiple Output
- Alternative technology (RF/Optics)



Future work

- Development of network control algorithms for underwater sensor networks that address the challenges posed by the underwater domain.
- Test and verification scheme of shallow water model.
- Develop control algorithms for resource management in passive sonar where processing is a limited resource.

Outcomes

- Form the basis of PhD project concerned with Adaptive Intelligent Underwater Sensor Networks.
- To provide a quantitative assessment of techniques enabling underwater communication for shallow water using acoustics or other assisting technologies such as RF or optics.
- To enable a mean of comparison between performance when varying the topology of the network or some of the operation parameters.

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