ICEX 2020 MIT Autonomous Underwater Vehicle: *Communications and Tracking*

gobysoft.org aquatic software

Massachusetts Institute of Technology

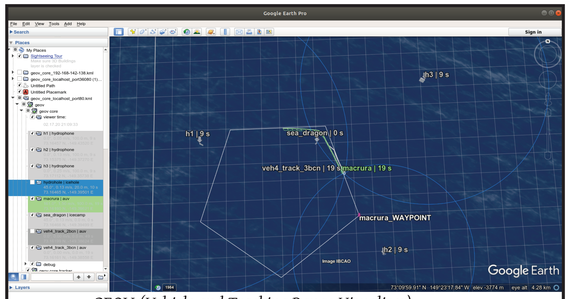
Unified Command and Control Topside

~ Goby Communications

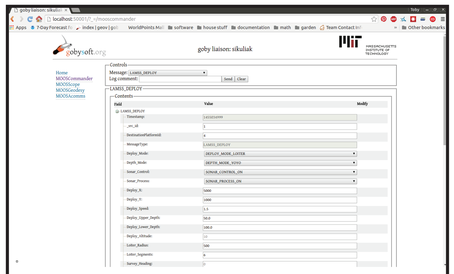
~ WHOI / MIT Tracking Range for Ice Camp and Vehicle Locations (Integrated Communications and Navigation - see right panel):
- Freewave (radio) connection to independent ice buoys (HF 10 kHz acoustic 4-element Rx, 1-element Tx)
- VHF 25kHz deckbox system in ice hole for backup / recovery communications

~ Google Earth interface for Ocean Vehicles (GEOV) Visualizer

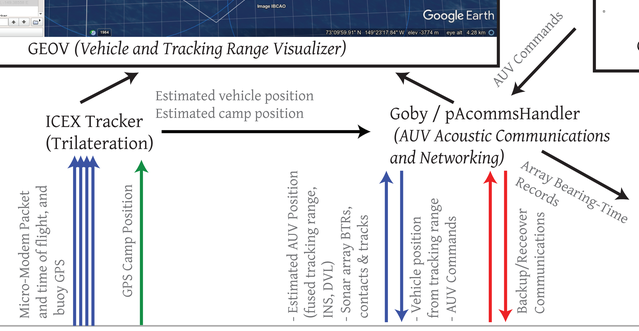
~ Goby Liaison Operator Command Interface



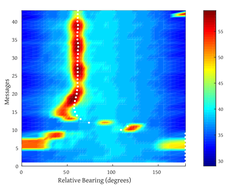
GEOV (*Vehicle and Tracking Range Visualizer*)



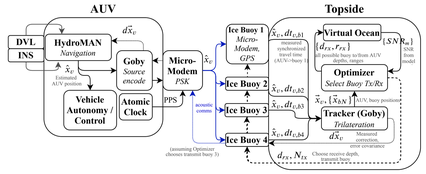
Goby Liaison (*Command Interface*)



BTR Display (*Bearing-time record from the AUV array*)



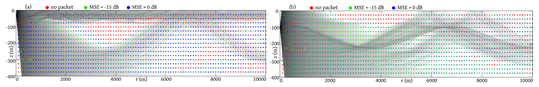
Integrated Communications and Navigation Network



~ Single acoustic transmission from vehicle allows for both tracking and digital acoustic communication

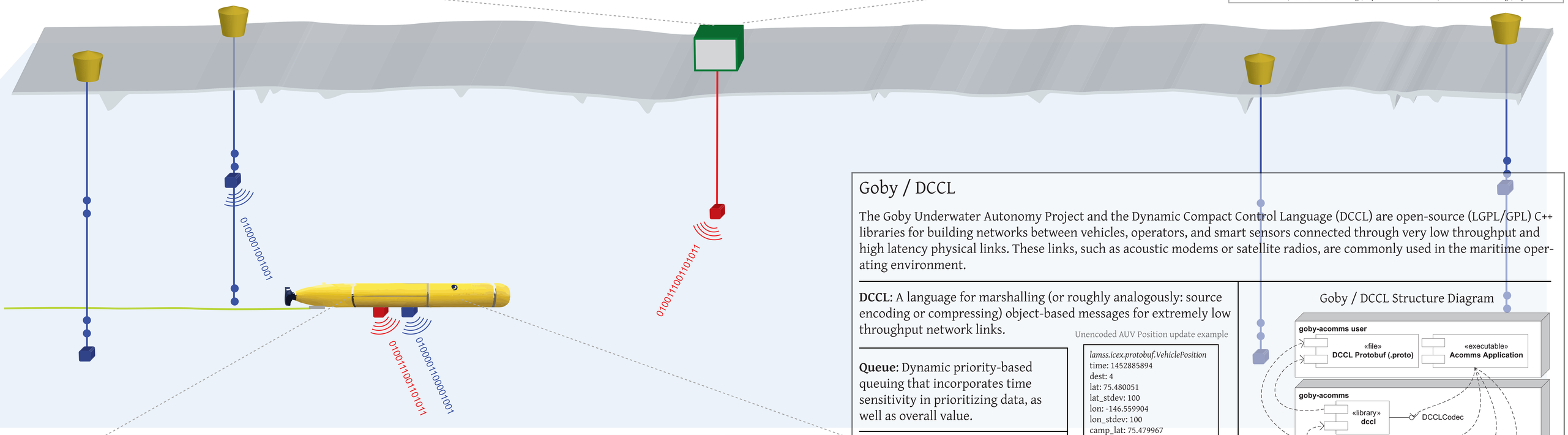
~ Vehicle navigation is updated on next downlink (topside -> AUV) message

~ Dual receive and transmit depths are automatically selected between by a "Virtual Ocean" model predicting the best performance.



Buoy "shallow layer" (33 meter) transmit/receive versus AUV range/depth

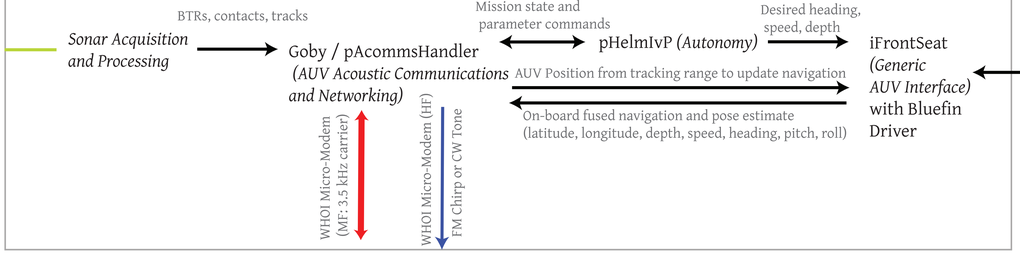
Buoy "deep layer" (100 meter) transmit/receive versus AUV range/depth



Macrura AUV Payload

~ MOOS-IvP Autonomy

~ Goby Communications
- ~ WHOI Micro-Modem High Frequency (HF) for Digital Acoustic Communications and Tracking
- ~ WHOI Micro-Modem Very High Frequency (VHF) for Digital Acoustic Communications (recovery/backup)



Bluefin AUV Main Vehicle Computer

Bluefin Huxley Architecture

Goby / DCCL

The Goby Underwater Autonomy Project and the Dynamic Compact Control Language (DCCL) are open-source (LGPL/GPL) C++ libraries for building networks between vehicles, operators, and smart sensors connected through very low throughput and high latency physical links. These links, such as acoustic modems or satellite radios, are commonly used in the maritime operating environment.

DCCL: A language for marshalling (or roughly analogously: source encoding or compressing) object-based messages for extremely low throughput network links.

Unencoded AUV Position update example

```
lamss.icex.protobuf.VehiclePosition
time: 1452885894
dest: 4
lat: 75.480051
lat_stdev: 100
lon: -146.559904
lon_stdev: 100
camp_lat: 75.479967
camp_lon: -146.560049
```

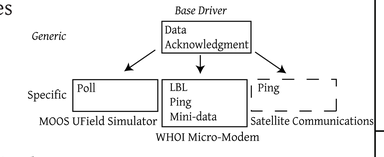
BygGEQnzN0zIwIL8A9knDbtnIP8A

Same message encoded (using DCCL) (shown as base64): 21 bytes total

Queue: Dynamic priority-based queuing that incorporates time sensitivity in prioritizing data, as well as overall value.

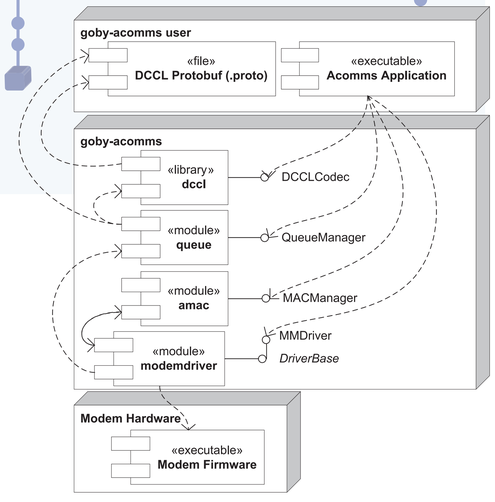
AMAC: Time division multiple-access (TDMA) medium access control (MAC) for multiple vehicles to share the same frequency band.

ModemDriver: A flexible interface that allows incompatibilities between different modems to be abstracted, while preserving unique functionality (e.g. long-baseline pings on an acoustic modem) when desired.



More information:
Goby: http://gobysoft.org/doc/3.0/
DCCL: http://libdccl.org

Goby / DCCL Structure Diagram



Partial list of other projects that have or are using Goby and/or DCCL:
- ~ DARPA Distributed Agile Submarine Hunting (DASH)
- ~ Bluefin Robotics TOPICS Communications Architecture
- ~ DARPA Robotics Challenge (DRC)
- ~ ONR Shallow Water Autonomous Mine Sensing Initiative (SWAMSI)
- ~ NATO Centre for Maritime Research and Experimentation AUVs