Goby:

A Framework for Scientific Autonomous Marine Vehicle Collaboration

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Perfection is achieved, not when there is nothing more to add, but rather when there is nothing more to take away.

— *Antoine de Saint-Exupéry, Terre des Hommes (1939)*

Nasty complexities

Why is marine autonomy difficult?

Physical problems:

- Expensive vehicles
- Limited power
- Poor communications

Human problems:

- Lack of interoperability standards
- Lack of networking / computer systems expertise
- Lack of comprehension of scientific needs by computer folks

What is Goby?

- Goby-Core is an open framework for communication based on ZeroMQ:
  - Inside a vehicle (UNIX sockets, TCP / UDP)
  - Between vehicles over ethernet links (TCP / UDP)
  - Between different autonomy systems (MOOS, LCM...)
  - Amongst applications written in 20+ languages
  - Using different messaging protocols

  (CMOOSMsg, Google Protocol Buffers, LCM types, boost::serialization...)
- Goby-Core also includes an
  - SQLite3 / PostgreSQL logger (`goby_database`)
  - Web browser based scope, command, etc. tool (`goby_liaison`)

What is Goby?

- Goby-Protobuf
  - implements Goby-Core for C++ and Google Protocol Buffers
  - is a high quality, easy to learn replacement for existing architectures like MOOS and LCM for new projects.
- Goby-Acomms (another talk) provides a field-tested networking system for acoustic and other slow links that seamlessly integrates into Goby-Protobuf
- Goby-MOOS provides
  - `pAcommsHandler` & `iCommander` acomms apps
  - a MOOS to Goby gateway
  - .alog file to/from SQLite3 conversion tools.
  - CMOOSMsg to Protobuf translators

Why Goby-Protobuf?

Much of Goby-Core (and the Protobuf implementation) was motivated to write the "next generation" MOOS.

What works in MOOS:

- Discrete processes
- Publish / subscribe
- Easy to learn
- Choice of a high quality, general purpose language (C++)

Goby-Protobuf: Typed Messages

MOOS: Untyped variables lead to trouble in large projects

Data sources (e.g. sensors) provide *objects* not single scalars or strings. Examples:

- vehicle position and Euler angles.
- acoustic environment

MOOS requires either

- splitting the object into scalars (problems “restitching”)
- creating custom strings: costly in programmer time, CPU time, and prone to subtle errors.

Goby-Protobuf: Typed Messages

Goby: Strictly typed variables allow compile time type checking and integrated support for arbitrarily complex objects.

Google Protobuf

```
message HelloWorldMsg
{
  required string telegram = 1;
  required uint32 count = 2;
}
```

C++

```
static int i = 0;

HelloWorldMsg msg;
msg.set_telegram("hello world!");
msg.set_count(++i);

publish(msg);
```

Static types allows Doxygen-style analysis of messaging

Goby-Protobuf: Configuration

MOOS: Configuration is prone to syntactical and type errors

`CProcessConfigReader` does not provide

- Checking for values that shouldn't exist
- Checking that required values do exist
- Type checking on values

Other oddities include

- Removal of all spaces from strings
- Confusion between `CMOOSFileReader::GetValue` (reads from entire file) and `CProcessConfigReader::GetConfigurationParam` (reads from block)
- Difficulty in reading repeated values

Goby-Protobuf: Configuration

Goby: Configuration schema allows strict behind-the-scenes validation

Application author schema:

```
message MyConfig {
optional double speed = 1 [default=3];
required string port = 2;
}
```

Valid configuration file:

```
speed: 34.25
port: "/dev/ttyUSB1"
```

Invalid configuration file (caught at launch):

```
speed: “high”
prt: "/dev/ttyUSB1"
```

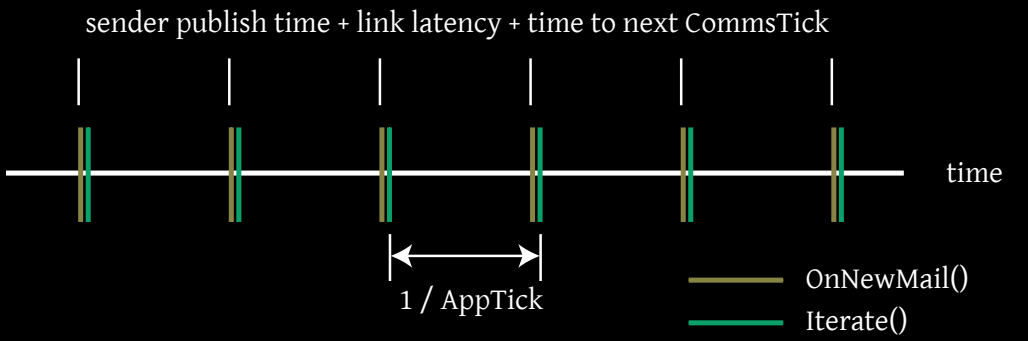
wrong type

typo - no field “prt”

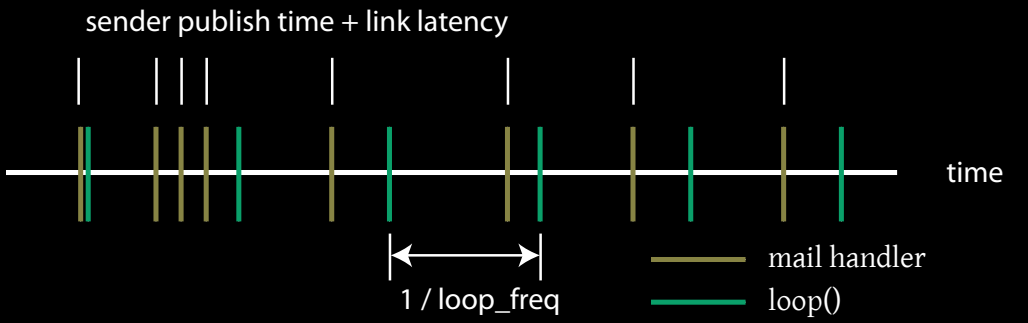
Goby-Protobuf: Asynchronous

MOOS: Messaging is done synchronously (`CommsTick` frequency)

MOOS messaging is done on a regular frequency, leading to artificial and unnecessary latencies.



Goby: Messages are delivered asynchronously, so latencies are governed by contraints of the physical link(s) only.



“Legacy code” often differs from its suggested alternative by actually working and scaling.

— *Bjarne Stroustrup,*
<http://www2.research.att.com/~bs/bs_faq.html#legacy>

Goby-Core: Interoperability

Much good work has already been done and tested, so we

- Want to use existing marshalling schemes (e.g. `CMOOSMsg`), existing transports (MOOS TCP) to interface "legacy" code to Goby-Protobuf
- Want to use favorite programming language (good code in several languages is better than bad code in one)

How?

Split the transport (e.g. TCP) and data marshalling (e.g. Protobuf) into separate entities.

Goby-Core: Interoperability

Goby-Core adds a thin header for existing marshalling schemes: [MarshallingScheme][Identifier][Data]

- *Marshalling scheme* (32 bit unsigned int). String = 1, Protobuf = 2, CCL = 3, MOOS = 4, DCCL = 5, LCM = 6 ...
- "C style" string *identifier* (variable length):
  {Type Name} + '/' + {Group Name} + '/' + {Subgroup Name} ... + '\0'
  - MOOS: "CMOOSMsg/DB_TIME/"
  - Protobuf: "SomeMessage/"
  - LCM: "my_lcm_type/my_lcm_channel/"
- Data (variable length) encoded as defined by *marshalling scheme*.

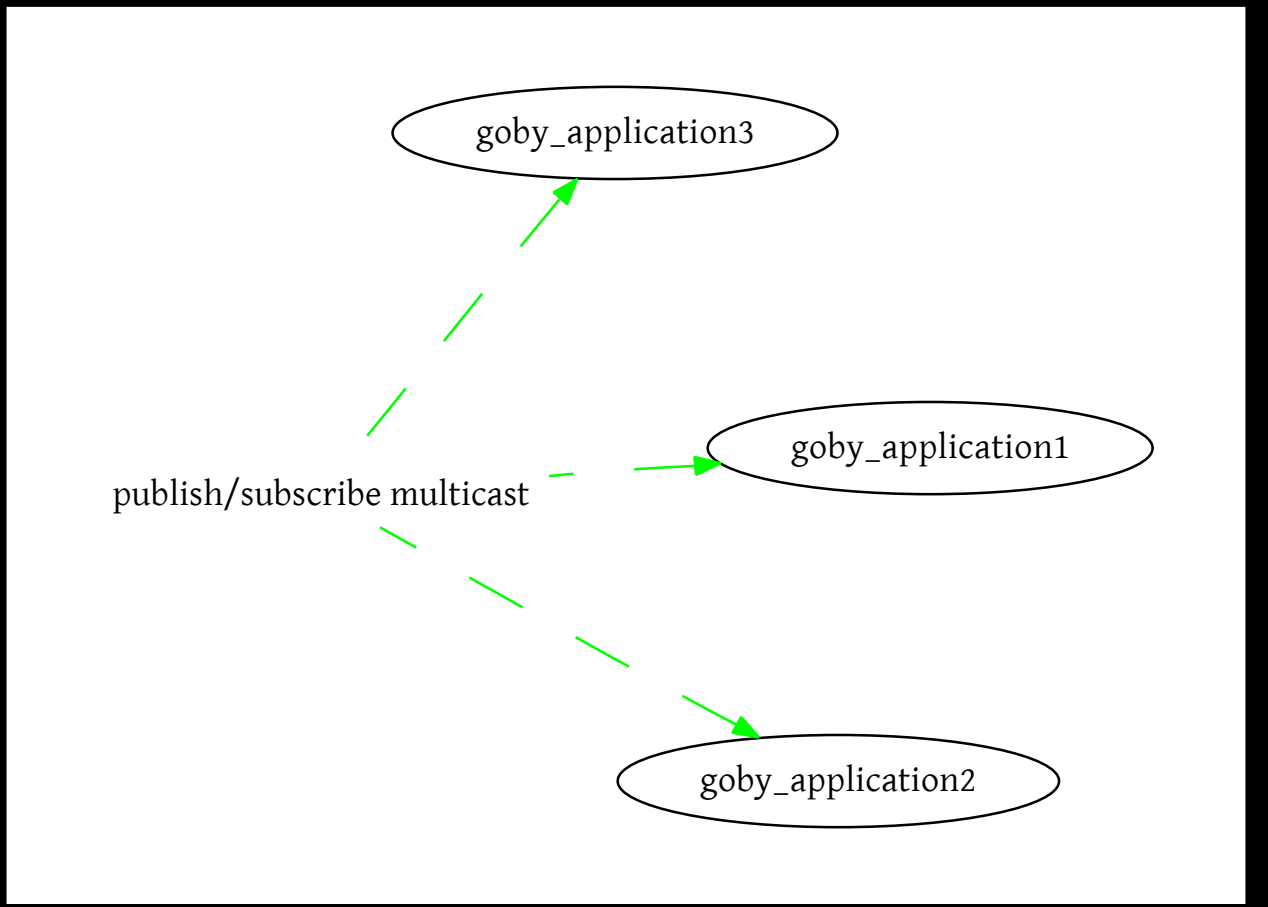
Goby-Core: Transport

Intravehicle and over ethernet, Goby-Core uses ZeroMQ:

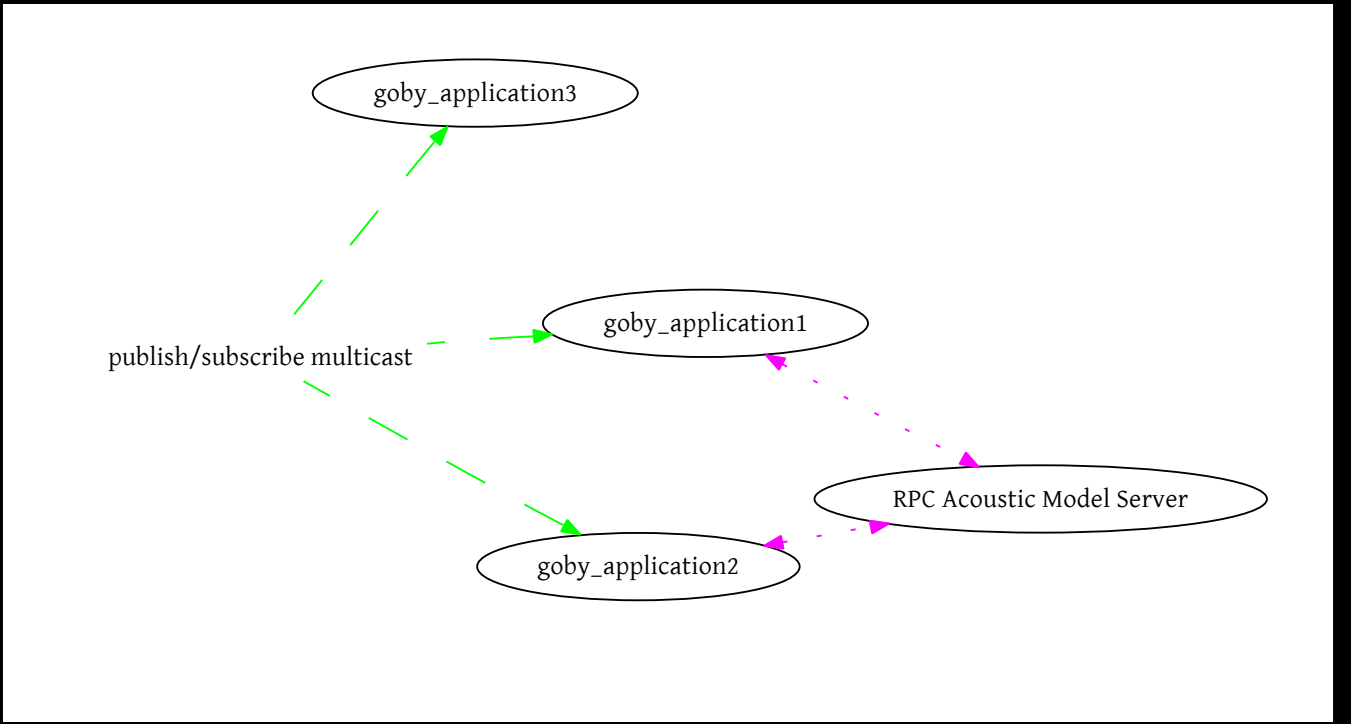
- Brokerless (e.g. no MOOSDB) abstraction of
  - TCP
  - PGM (reliable multicast over UDP)
  - UNIX sockets
- Mimics well known UNIX sockets API in 20+ languages
- Abstracts datagrams and streams into “messages” (message = a variable length collection of bytes)

Over slow links, Goby-Core uses Goby-Acomms. Selection and routing is handled by `goby_router`.

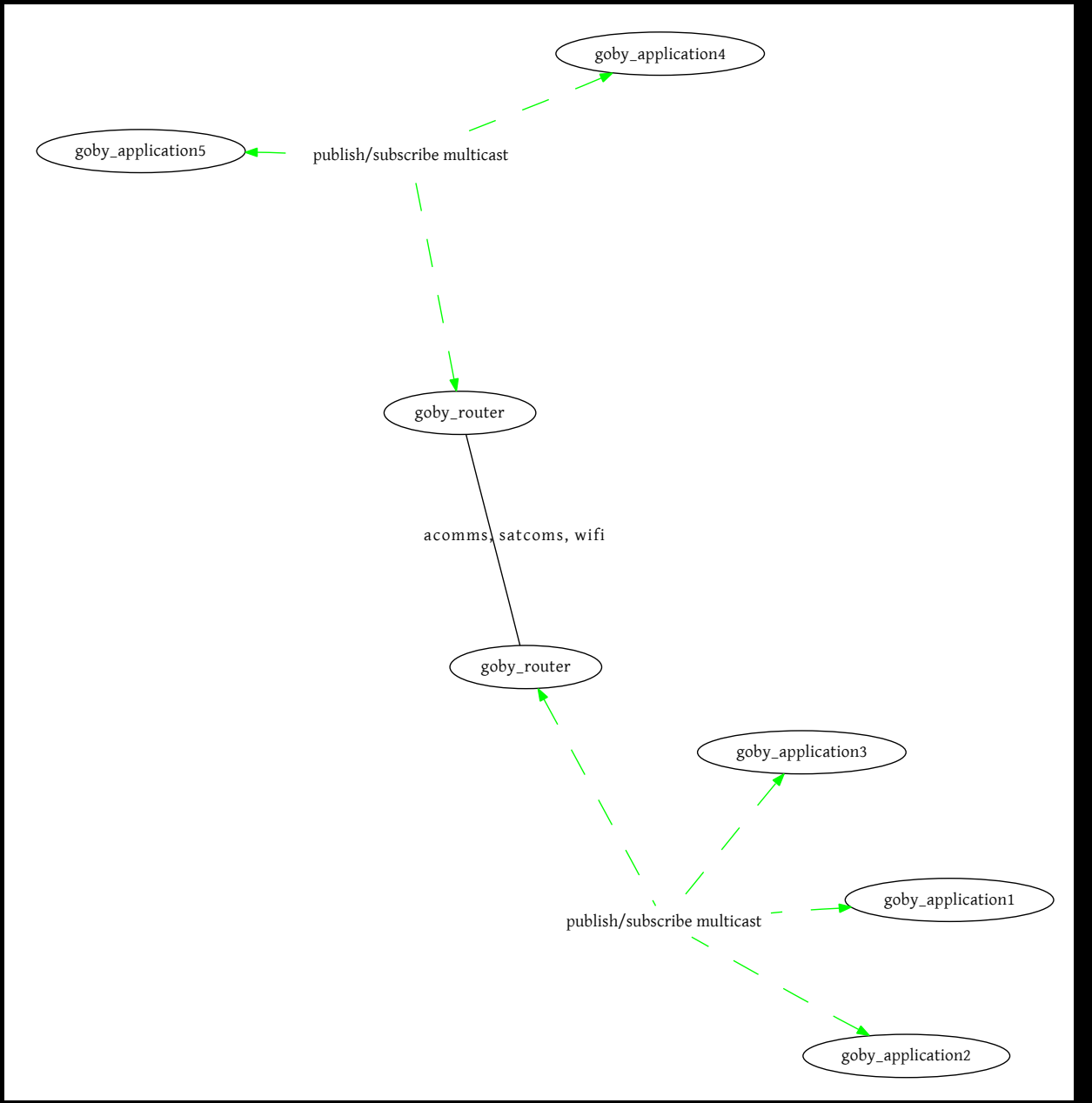
Topologies: Simple Goby Platform



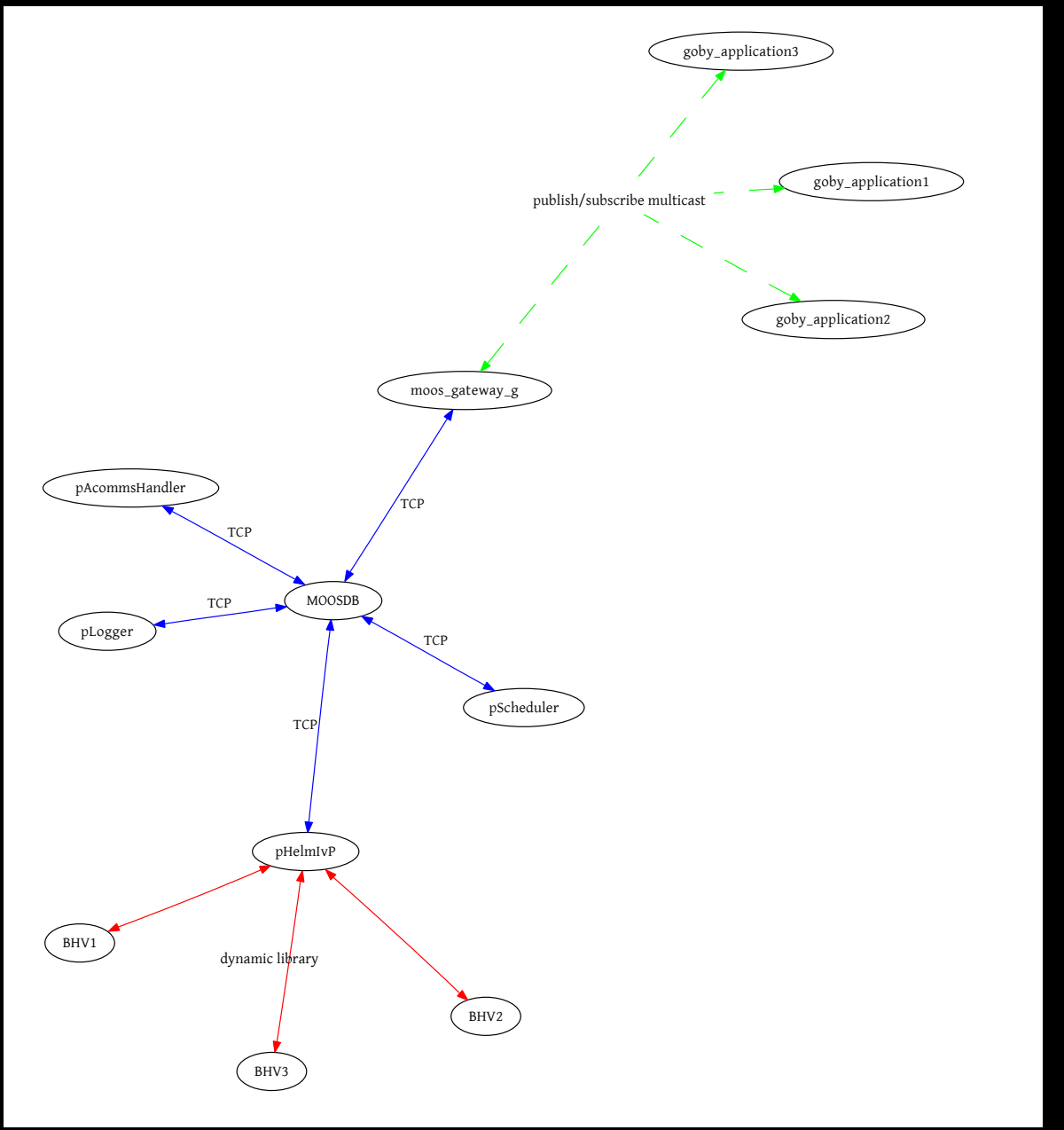
Topologies: Goby pub-sub and RPC



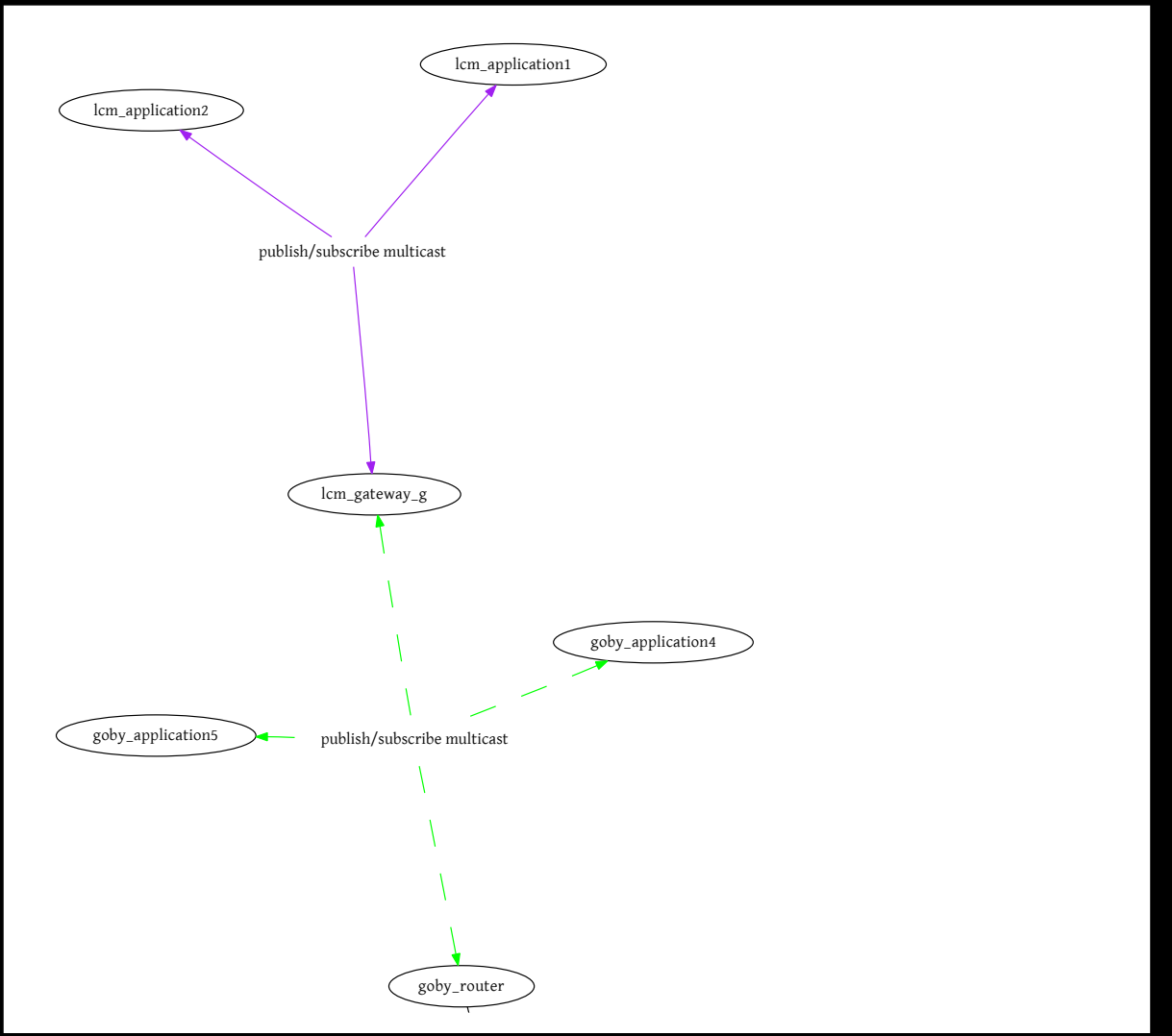
Topologies: Two Goby Platforms



Topologies: Goby & MOOS

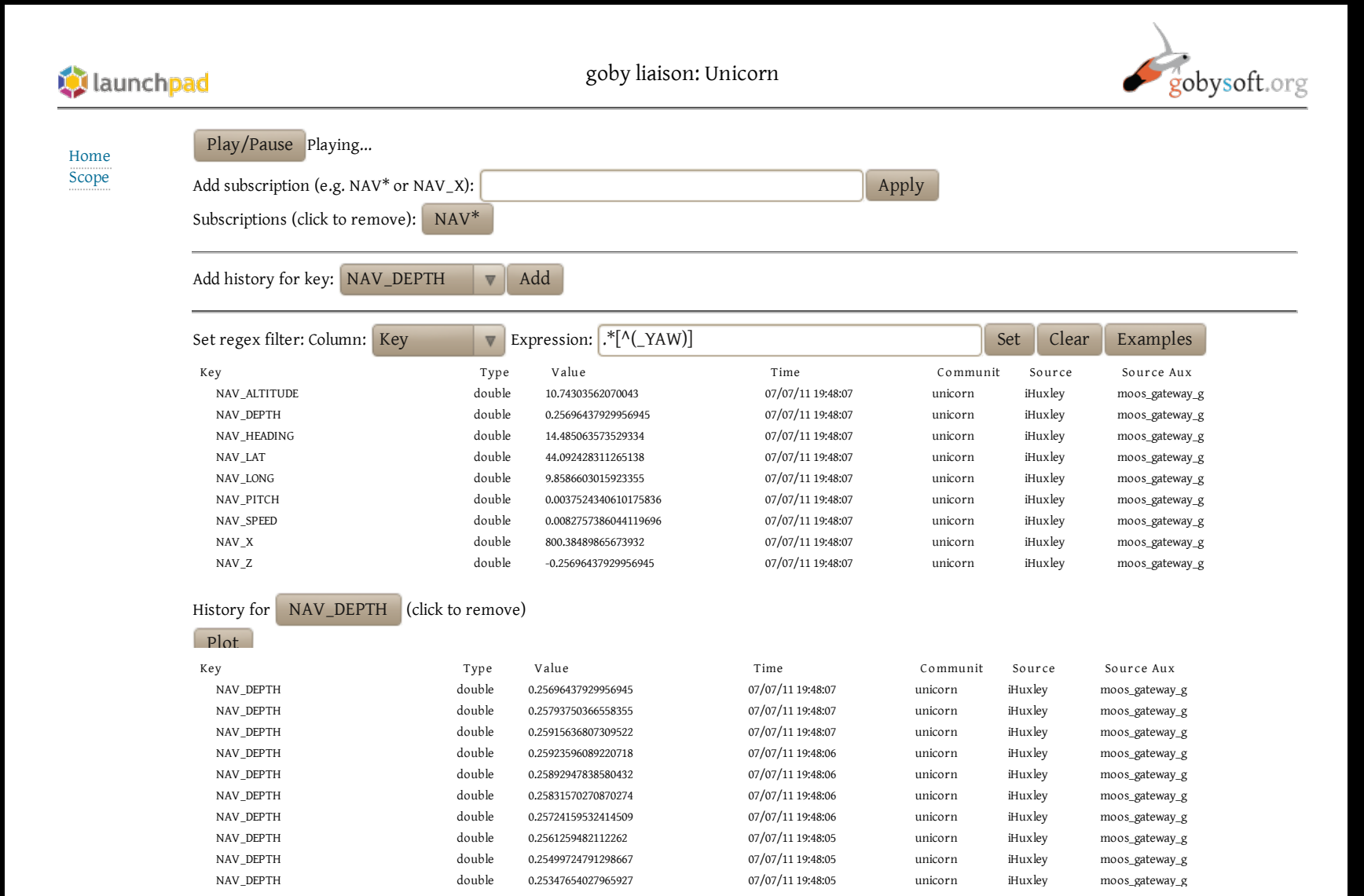


Topologies: Goby & LCM



Goby Liaison

An extensible web tool, shown "scoping" CMOOSMsgs:



Goby Database

An SQL logger currently with CMOOSMsg and Protobuf plugins:

query:
```
select double_value
    from cmoosmsg
    where key='NAV_X'
      and double_value > 0;
```

versus with .alog file:
```
grep " NAV_X" file.alog | sed "s/  */ /g"
| cut -d " " -f 4 | egrep "[^(-)]"
```

Goby Database: Alog converter

`alog2goby_db` converts a MOOS .alog file (from `pLogger`) to an SQLite database similar to that generated by `goby_logger`.

Features:

- Support for CMOOSMsg
- Support for `scanf`-like string parsing of MOOS strings into Google Protobuf objects. E.g. NMEA-0183 parsing.
- Support for key=value string parsing of MOOS to Protobuf. E.g. NODE_REPORT parsing (`Name=AUV1,X=2300,Y=5023,DEPTH=3,...`).

Goby Project

- Free open source (GNU Public License 3)
- Easily accessible: http://launchpad.net/goby
- Documented: http://gobysoft.org/doc/1.0/
  http://gobysoft.org/wiki
- Organized releases: version 1 stable (acoustic comms only); version 2 (contents of this talk) coming this fall
- Well tracked bugs

Please contribute (use the software, report bugs, write code for Goby). Any feedback is helpful and welcome.

This can be your project as much as ours.

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