Essential infrastructure tools

- Message passing
  - Modularity
    - Encourages abstraction and decomposition of large problems into well-defined sub-problems
    - Software reuse
    - Fault tolerance
    - Creates viewports into system’s internal operation
- Logging, Playback
Example

- MIT DUC
  - 40 CPU cores
  - 22+ distinct modules
  - 60+ module instances
Modularization Example

- Laser driver
  - laser_t
  - object_position_t

- Red Ball Finder
  - laser_t
  - object_position_t

- Obstacle Tracker
  - laser_t
  - obstacles_t

- Game Pad Drive
  - motor_t

- Motion Planner
  - object_position_t
  - obstacles_t
  - motion_planner_t

- Path Follower
  - motion_plan_t
  - motor_t

- Splinter
  - motor_t
  - pose_t
**LCM Type Definition Example**

```c
struct object_position_t
{
    int64_t utime;
    double distance;  // distance to object
    double theta;     // direction to object
}
```

```python
objectpos = new object_position_t();
objectpos.utime = System.currentTimeMillis()*1000;
objectpos.distance = 0.3;
objectpos.theta = -0.12;
```
laser_t.lcm

struct laser_t
{
    int64_t utime;

    // range data (meters)
    int32_t nranges;
    float ranges[nranges];

    // intensity data, in sensor-specific units
    int32_t nintensities;
    float intensities[nintensities];

    // the angle (in radians) to the first point in nranges,
    // relative to the laser scanner's own coordinate frame.
    float rad0;

    // the number of radians between each successive sample
    float radstep;
}