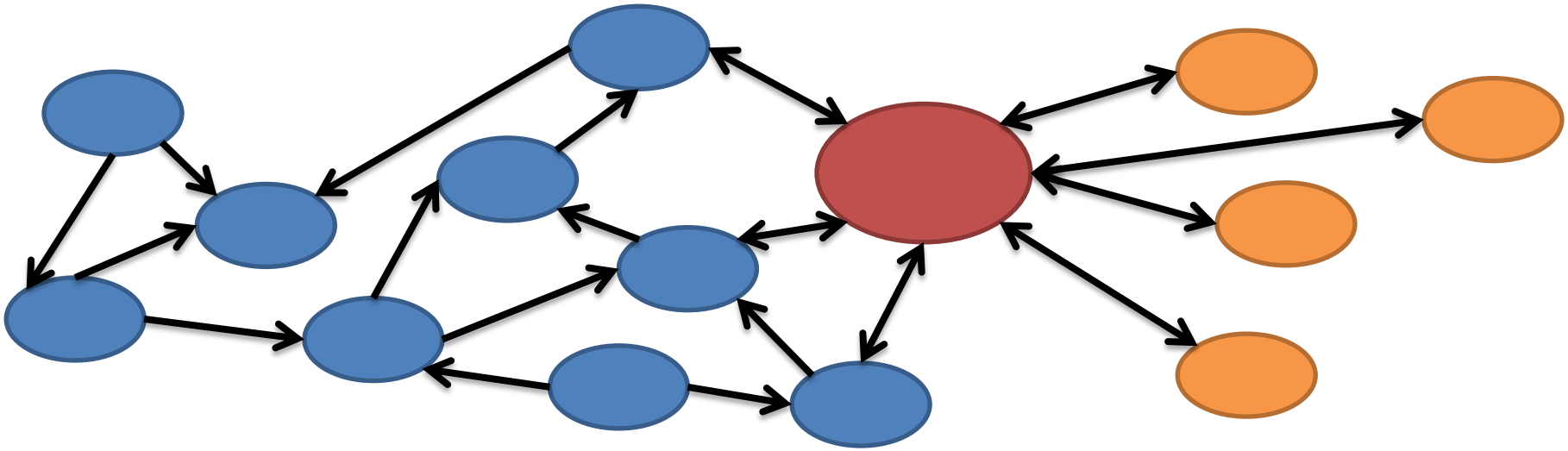


Bridging ROS to Embedded Systems

Morgan Quigley
Open Source Robotics Foundation

Many images via Wikipedia

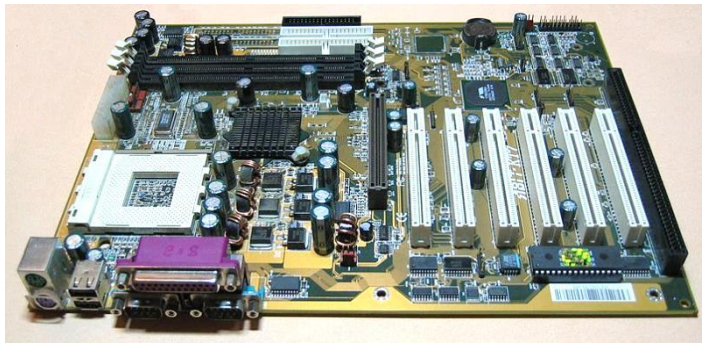
Overview

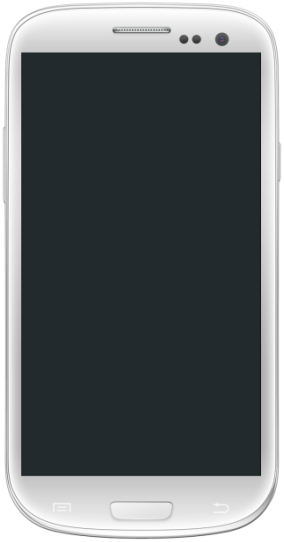
- survey of the diversity of embedded systems and some bridging approaches using ROS
- not intending to argue for/against any particular method for all situations
  - best method is often implied by the application

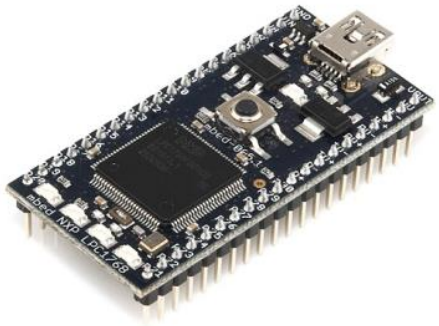
Motivation

- all robots have embedded systems.
  - it's not "if" but "how" we talk with them
  - lasers, cameras, motors, radios, etc.
- sometimes, we have control over firmware
- sometimes, we don't
- many different situations = many approaches

Huge Range of Embedded Systems



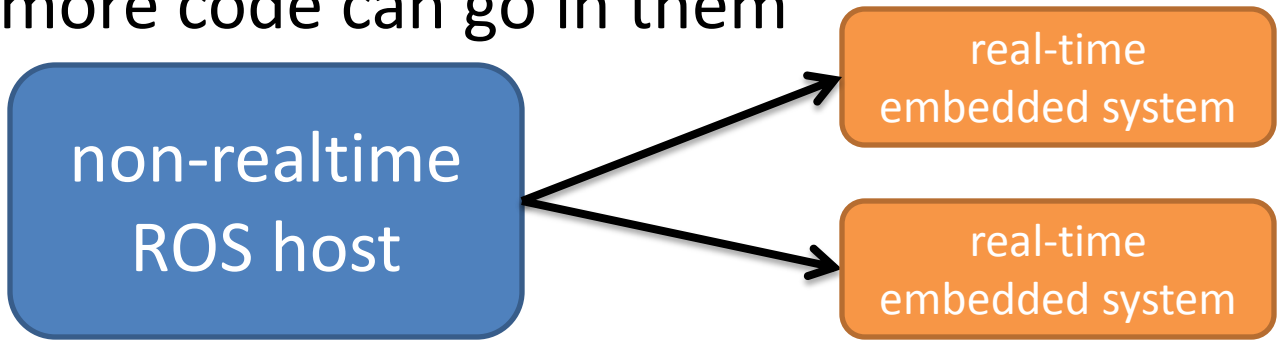




Images: Wikipedia

Why embed ?

- reduce cost, size, weight, power
- more powerful every year
  - massive market forces #embedded >> #pc's
- real-time requirements are hard/painful to mix with non-realtime code on full systems
  - isolate real-time requirements to embedded
  - more and more code can go in them



Popular Hardware Classes

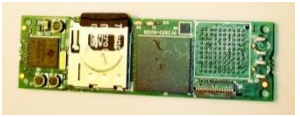
mini-ITX

PC/104

x86

Android

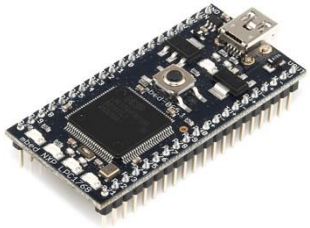
Raspberry Pi



Gumstix

BeagleBone

ARM-A



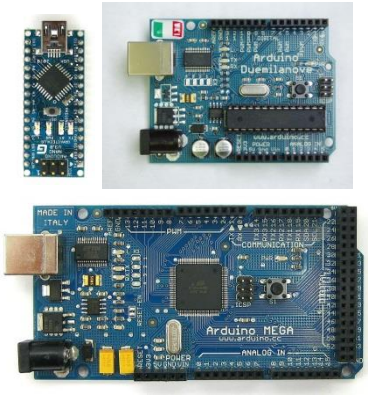
mbed

STM32 Discovery

Olimex ARM-USB-TINY-H

ARM-M

Teensy 2.0



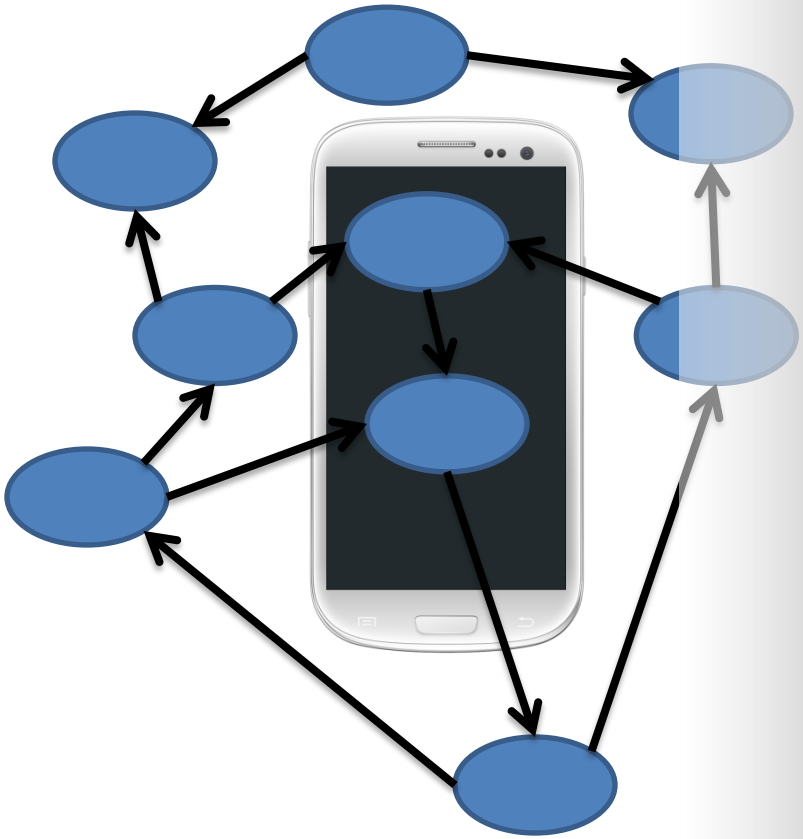
Arduino

AVR

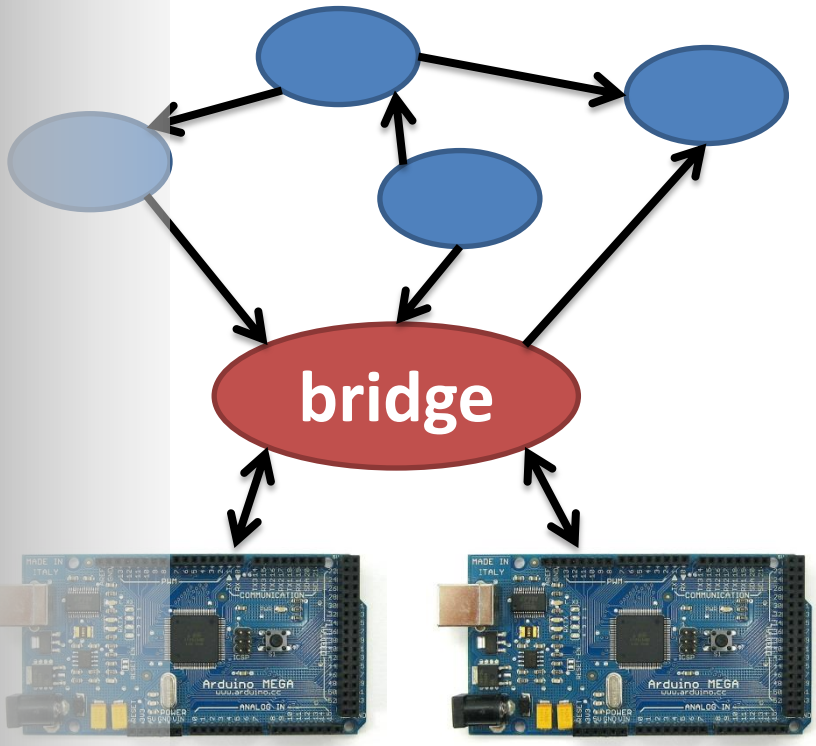
Images: Wikipedia

Two Extremes of Integration

“Unified”

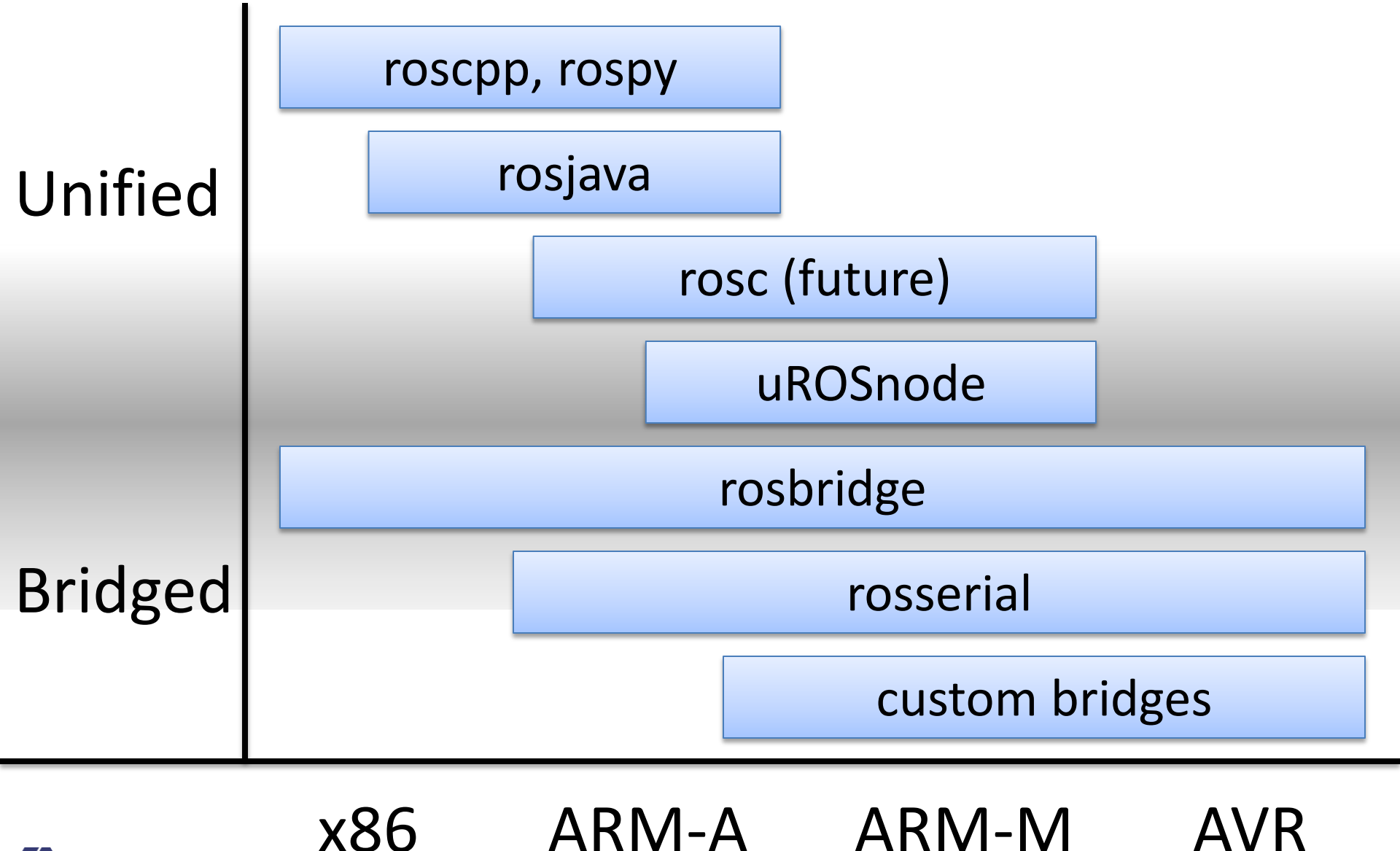


“Bridged”



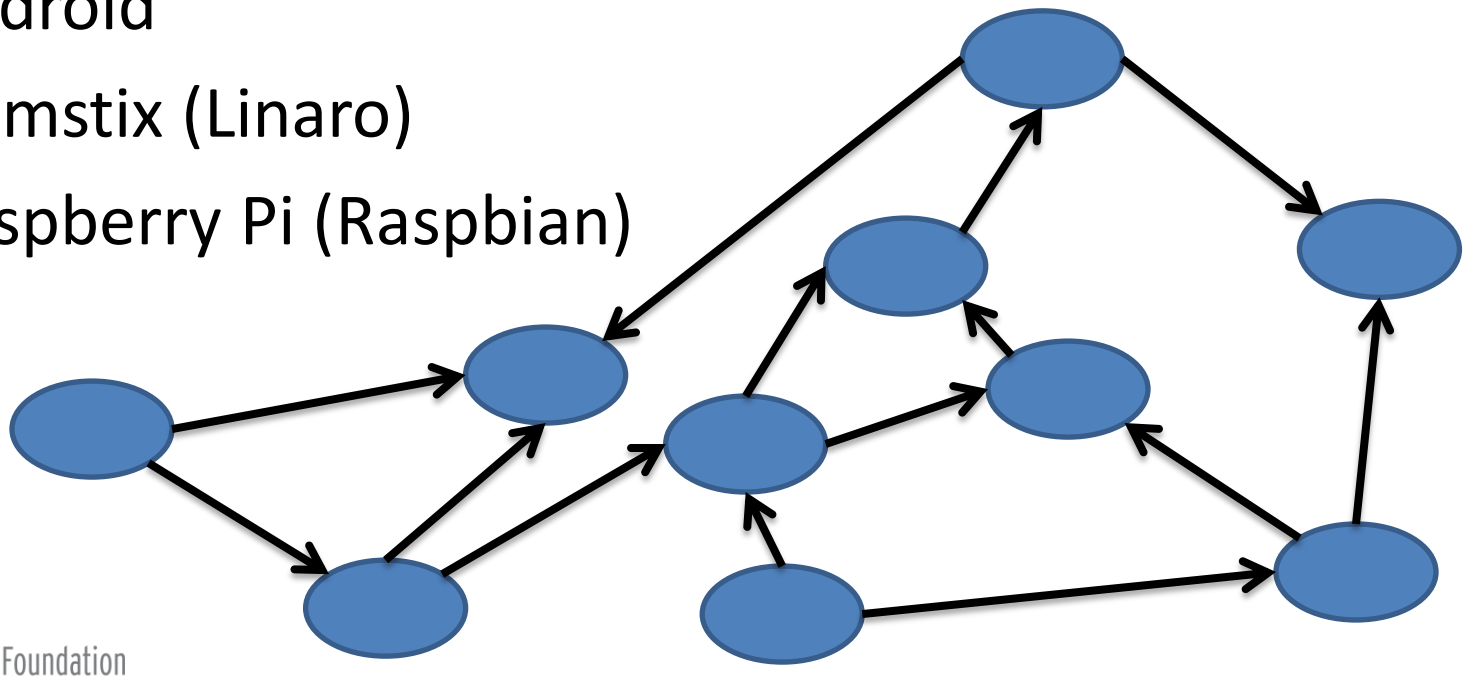
Images: Creative Commons

Images: Wikipedia


roscpp, rospy
rosjava
rosc (future)
uROSnode
rosbridge
rosserial
custom bridges
Unified
Bridged
x86
ARM-A
ARM-M
AVR

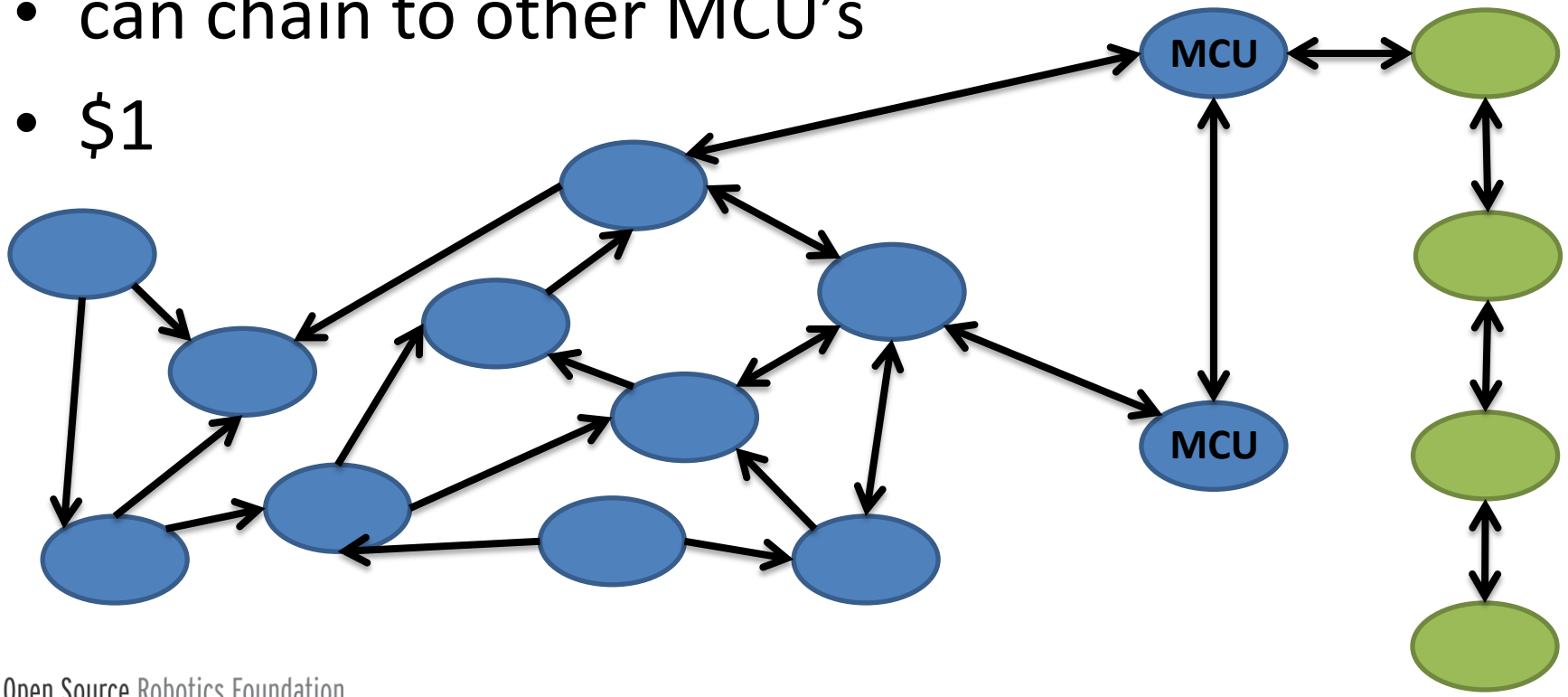
roscpp, rospy, rosjava

- ARM Cortex-A machines can run all of ROS
- Cross-compiling can be tricky. Start with binary distros and/or popular platforms:
  - Android
  - Gumstix (Linaro)
  - Raspberry Pi (Raspbian)



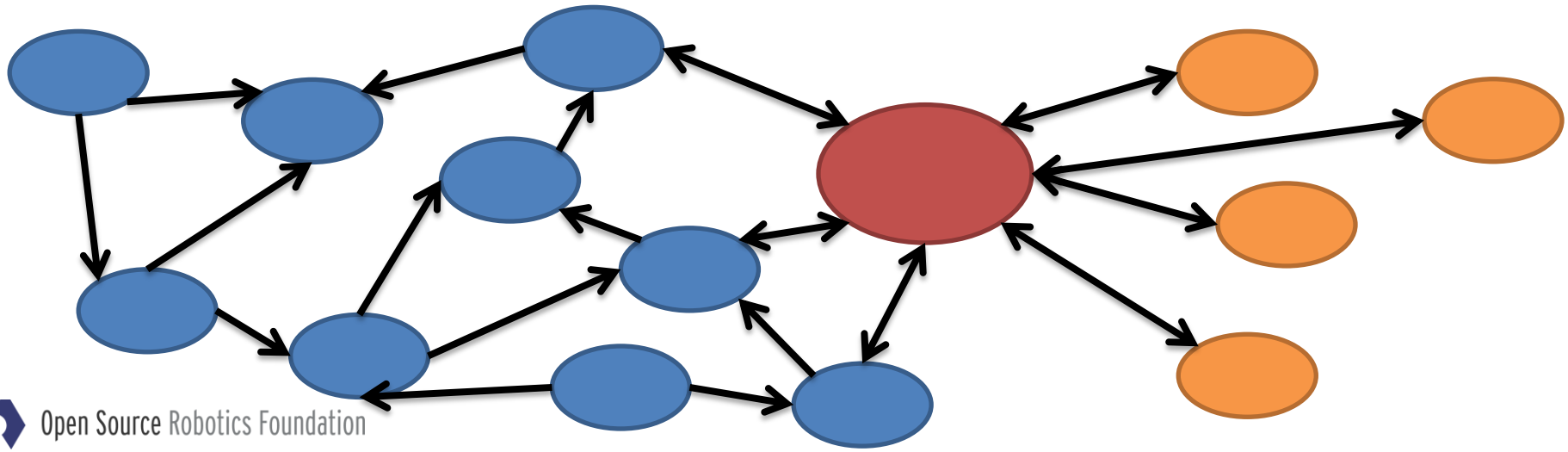
uROSnode and rosc

- ROS node functionality on ARM Cortex-M
- Small size via code generators
- can chain to other MCU's
- $1



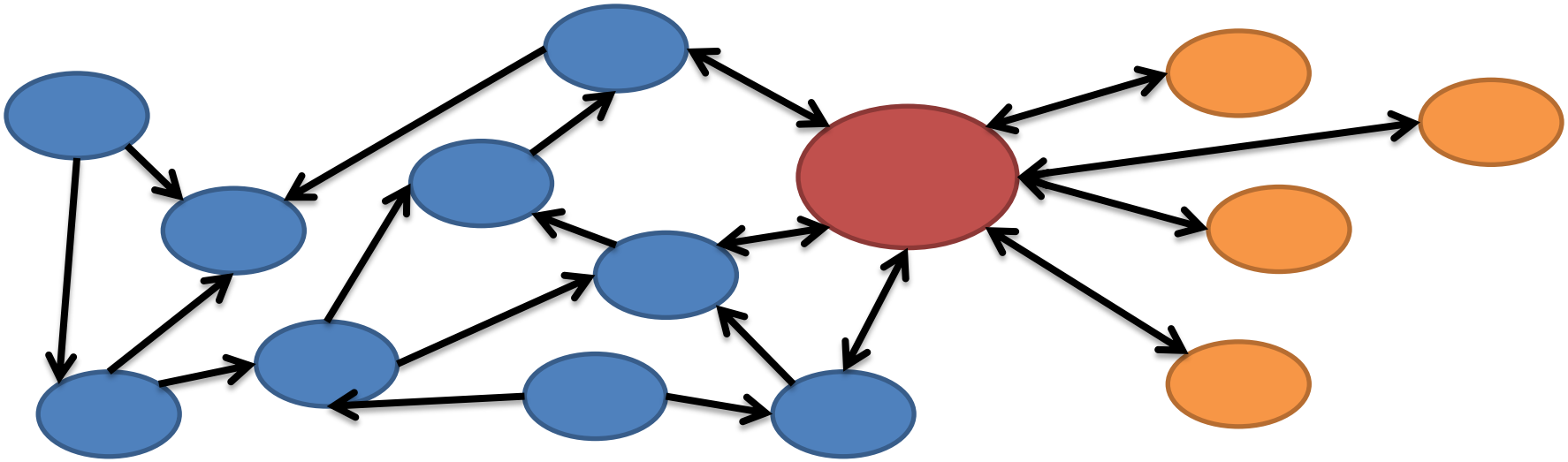
rosbridge

- JSON protocol to bridge to non-ROS systems
  - for example, connect web browsers to ROS
  - more broadly, connect sockets to ROS
- Much more at http://rosbridge.org and http://www.ros.org/wiki/rosbridge_suite



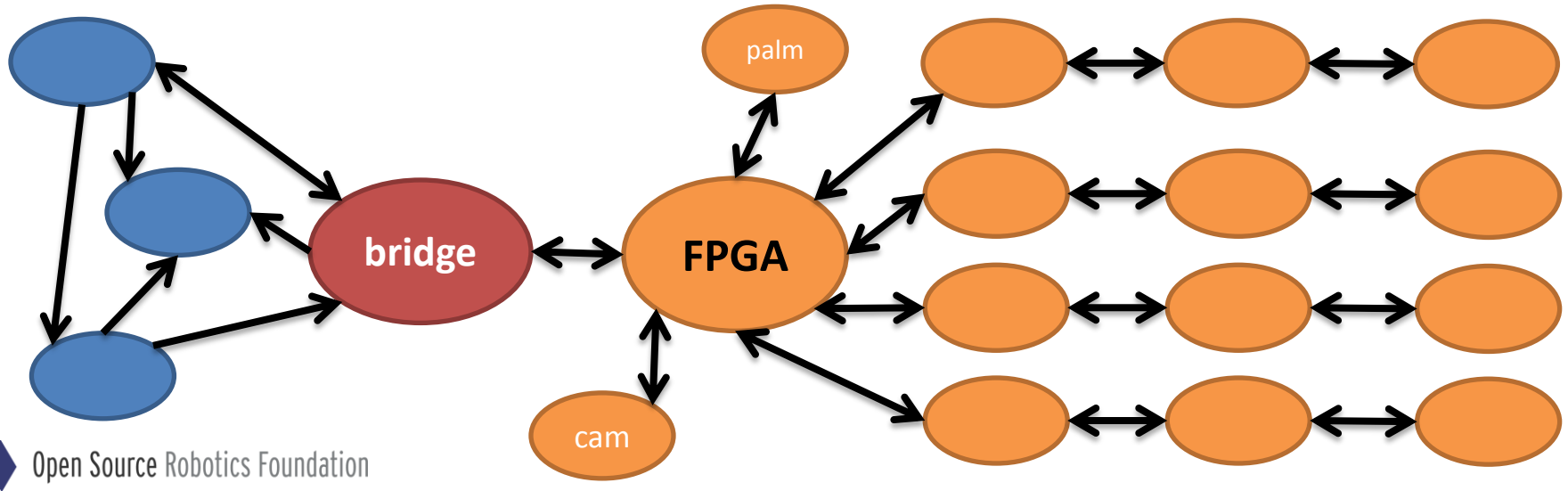
rosserial

- Bridges selected topics between a ROS system and a serial stream: UART, XBee, etc.
- Ports: Arduino and generic embedded linux
- http://www.ros.org/wiki/rosserial



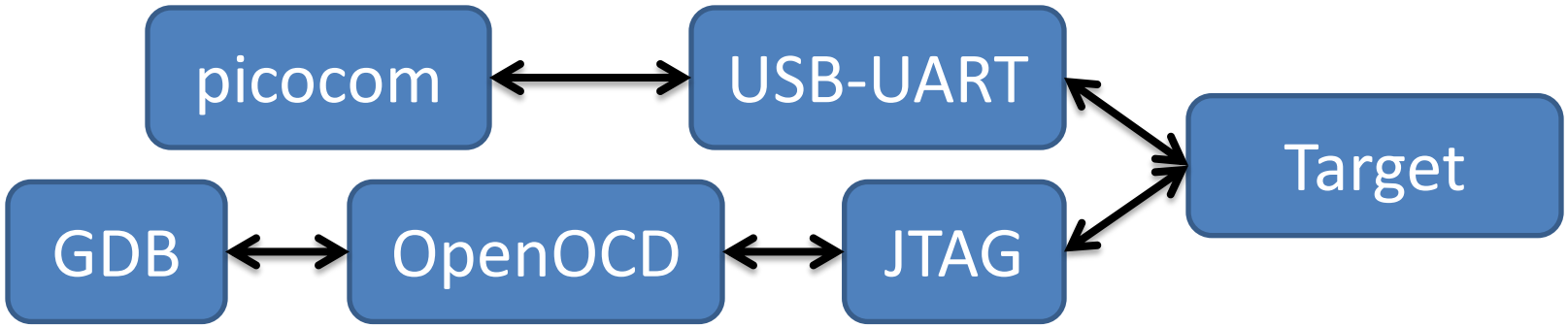
Custom Bridges

- Useful to implemented proprietary protocols, unusual data links, complex inter-system communications, etc.
  - hokuyo_node (and 1e6 other drivers)
  - Sandia Hand: https://bitbucket.org/osrf/sandia-hand



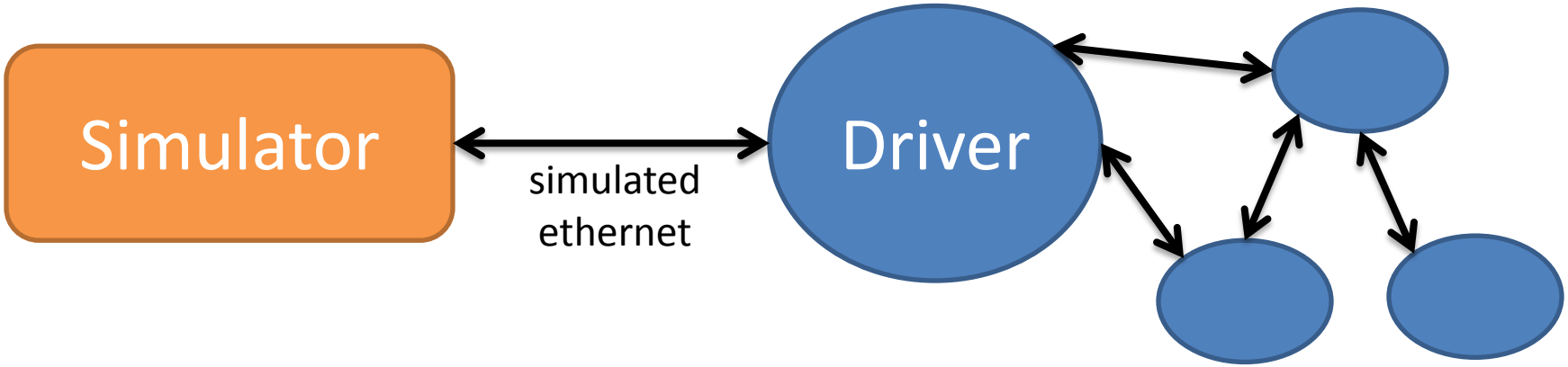
Cortex-M cross compiling, debugging

- http://bitbucket.org/osrf/sandia-hand
  - downloads a version of arm-gcc
  - clones and builds OpenOCD
  - CMake rules for cross-compiling Cortex-M targets
  - GDB server and client targets, disassembling, etc
  - custom bootloaders to support UDP, rs485, etc.



Xilinx FPGA simulation

- http://bitbucket.org/osrf/sandia-hand
  - Makefile rules for synthesis, download, flash burn
  - Rules for simulation using Icarus Verilog (GPL)
  - Gigabit ethernet emulation to/from simulation
  - Debug comms between simulated FPGA and driver



Acknowledgments and Summary

- ros-sig-embedded
- ROS for Products Workshop

- furious activity at many levels of embedded
- lots of interest in a portable, lightweight ANSI C client for both bare metal and various RTOS'es
  - next talk: **rosc**