State of Ubuntu and ROS on ARM
Why ARM?

Performance per Dollar
quad-core, 1GHz+ CPUs
$60-$200

Power Consumption
usually < 10W

Size
usually less than 15x15cm

Everything Included
History of ROS on ARM

- **2009**: gumros
  - Jostein Jacobsen
- **2010**: gumrosAlt
  - Daniel Stonier
- **2011**: eros
  - Daniel Stonier
- **2012**: TurtleCore
  - Rob Linslata
  - ROS Hydro on ARM
  - Austin Hendrix
- **2013**: meta-ros
  - BMW, Lukas Bulwahn
  - ROS Groovy on ARM
  - Austin Hendrix
  - beagle-ros
  - Victor Mayoral
- **2014**: ROS Hydro with PCL and Navigation
- **2015**: ROS Indigo on ARM
Why Ubuntu?

- Easy to install
- Lots of ARM boards already supported
- Already supported by ROS, minimal changes for ARM
- Victor, the original developer of BeagleROS (ROS on Ångstrom) has switched to Ubuntu.
## Comparison with OpenEmbedded

### Ubuntu
- Binary ROS packages
- Is compiled for a generic ARM architecture
- Installation with usual Ubuntu tools (dpkg, apt, etc.)

### OpenEmbedded (meta-ros)
- A cross-compilation tool chain for ROS packages based on catkin
- Compiles all packages from source
- Supports many architectures: ARM, MIPS, PowerPC, and more!
### Comparison with OpenEmbedded (2)

<table>
<thead>
<tr>
<th>Ubuntu</th>
<th>OpenEmbedded (meta-ros)</th>
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<tbody>
<tr>
<td>✤ easy and quick installation</td>
<td>✤ easy to adjust to new machines and architectures</td>
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<tr>
<td>✤ no need to compile the basic ROS packages from source</td>
<td>✤ allows changes to the basic ROS packages</td>
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<tr>
<td>✤ common Ubuntu feel</td>
<td>✤ small Linux kernels and images</td>
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<tr>
<td>✤ additional compilation is on-board</td>
<td>✤ needs a big build machine for compilation</td>
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<td></td>
<td>✤ needs some setup to get build machine and tool chain running</td>
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Package Counts

- **Groovy**: 495 packages
  - 929 upstream
- **Hydro**: 1035 packages
  - 1506 upstream
- **Indigo**: 772 packages
  - 995 upstream
What Works?

- PCL
- Navigation
- libfreenect driver
- OpenNI2
- OpenCV
- Camera drivers
What Doesn’t Work?

- OpenNI driver
- Third-party x86 binaries
- Lisp
  - Only works on Indigo and 14.04
- No Indigo on 13.10 (Saucy)
RViz and Gazebo

- RViz
  - Works **IF** your board has OpenGL support
  - Ok for simple tasks, slow for point clouds
  - No binaries yet. In progress

- Gazebo
  - Community reports that it works
  - No ARM binaries from upstream
Supported Platforms

❖ Must run Ubuntu or Linaro
  ❖ Linaro builds are customized builds of Ubuntu for specific CPUs and boards
❖ Same ROS to Ubuntu mappings as x86
  ❖ Groovy on Ubuntu 12.04 and 12.10
  ❖ Hydro on Ubuntu 12.04, 12.10 and 13.04
  ❖ Indigo on Ubuntu 14.04
❖ Lots of user-contributed reports for individual platforms
Supported Platforms (1)

- BeagleBoard xM
- BeagleBone Black
- PandaBoard
- Cubieboard 2
- Gumstix Overo
- FXI Cotton Candy
Supported Platforms (2)

- SolidRun CuBox-i Pro
- Odroid U3 and family
- Parallela
- Radxa Rock
- UDOO (Dual and Quad)
- NVIDIA Jetson TK1
Supported Boards (5)

- Qualcomm Snapdragon
- Inforce Computing: IFC6410
- Intrinsyc: DragonBoard APQ8074 (not shown)
Robots using ARM

- **ROSi**: Qualcomm’s TurtleBot with Snapdragon
- **Dan Barry**: Indoor Navigation
- **Erle Robotics**: rovers and quadcopters
- **Dagny (my robot)**: Indoor and outdoor navigation
- **Korean Odroid TurtleBot project**
- **Ubiquity Robotics**: Indoor navigation
- **Alex Teichman**: 3D perception research
ROSiie

Qualcomm’s Turtlebot with Snapdragon ARM CPU
ROSie

Qualcomm’s Turtlebot with Snapdragon ARM CPU
Dan Barry

Custom platform with Odroid U3, doing indoor navigation.
Fellow Robotics
Dan Barry

Custom platform with Odroid U3, doing indoor navigation.
Erle Robotics

ErleRover
ErleBoard
Erle Robotics

ErleCopters
Austin Hendrix

Dagny: Indoor and outdoor navigation
Korean Odroid Turtlebot Project

Turtlebot with Odroid X2

http://www.ros.or.kr/index.php/Install_ros_on_embedded
Ubiquity Robotics

Hercules: Indoor navigation
Alex Teichman

Asus Xtion Pro on Odroid U3
Perception research
For part of his PhD thesis, Alex used this to detect cats walking on countertops.
The final goal was to deter cats from being on the counters.

It turns out shooting them is less effective than expected.
Questions?
Surprise!

- Qualcomm is sponsoring ROS development for ARM!
- Official support for ROS on the Qualcomm Snapdragon
- ROS Indigo on Ubuntu in 3 months
- Android in 6 months
Links

❖ My Blog
 http://namniart.com

❖ Indigo on ARM
 http://wiki.ros.org/indigo/Installation/UbuntuARM

❖ Hydro on ARM
 http://wiki.ros.org/hydro/Installation/UbuntuARM

❖ Groovy on ARM
 http://wiki.ros.org/groovy/Installation/UbuntuARM

❖ OpenEmbedded
 http://wiki.ros.org/hydro/Installation/OpenEmbedded