Networking for ROS Users

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In a Perfect World:

• Nodes discover each other automatically
• Every node can talk to every other node

In the Real World:

• Nodes have to be told how to reach the master
• Firewalls, routing and DNS problems prevent nodes from talking to each other
The Basics

• IP addresses
• Routing
• Private IP addresses
• TCP and ports
• Network Address Translation (NAT)
• Name resolution and DNS
ROS Node Background

• Each node runs an XMLRPC server on a random port

• ROS nodes register themselves and their topics with the master

• Three steps and three DNS queries when subscribing to a topic
ROS Topic Setup
ROS Network Configuration

- Three environment variables for network config:
  - ROS_MASTER_URI
    - name and port of ROS master
  - ROS_HOSTNAME and ROS_IP (identical)
    - sets the hostname our node advertises to the master
  - Other nodes use this name to contact our node
  - Defaults to hostname
  - ROS_HOSTNAME takes precedence
Basic Debugging Tools

- rostopic info <topic>
- rosnode info <node>
- rosnode ping <node>
- ifconfig
- /etc/hosts
- /etc/resolv.conf
- man
$ rostopic info rosout_agg
Type: rosgraph_msgs/Log

Publishers:
* /rosout (http://elwood.local:65349/)

Subscribers: None
Advanced Debugging Tools

• netstat
• tcpdump
• iptraf
• route
• traceroute
• ip
Example: Bad DNS

- Node A on host alpha
- Node B on host beta
- Node A can publish to node B (topic chatter_A)
- Node A cannot subscribe to node B (topic chatter_B)
Example: Bad DNS

- alpha$ rostopic info chatter_B
  Type: std_msgs/String
  Publishers:
  * /B (http://beta:49189/)
  Subscribers: None

- alpha$ ping beta
  ping: cannot resolve beta: Unknown host

- alpha$ rosnodes ping B
  rosnodes: node is [/B]
  pinging /B with a timeout of 3.0s
  connection to [/B] timed out
Solution 1: Bad DNS

- Set ROS_IP on beta, to beta’s IP (10.0.0.2)
  
  - export ROS_IP=10.0.0.2
  
  - alpha$ rostopic info chatter_B
    Type: std_msgs/String
    Publishers:
    * /B (http://10.0.0.2:49354/)
    Subscribers: None
  
  - alpha$ rosnode ping A
    rosnode: node is [/A]
    pinging /A with a timeout of 3.0s
    xmlrpc reply from http://10.0.0.2:49211/
    time=337.913990ms
Solution 2: Bad DNS

- Add beta to `/etc/hosts` on alpha
- `/etc/hosts:
  10.0.0.2 beta`
- `alpha$ rostopic info chatter_B`
  Type: std_msgs/String
  Publishers:
  * `/B (http://beta:49354/)`
  Subscribers: None
- `alpha$ rosnode ping A`
  rosnode: node is `/A`
  pinging `/A` with a timeout of 3.0s
  xmlrpc reply from http://beta:49211/
  time=337.913990ms
NAT

- NAT: Network Address Translation
- Maps many internal IP addresses to a single public IP
- No inbound traffic by default
- ROS nodes outside cannot subscribe to nodes inside
- Solutions: use multimaster with a bridge, or VPN
Recommendations

- For small labs and hobbyists, use **dnsmasq**
- Combined DHCP and DNS server
- DNS records created on the fly when new hosts connect
- **dnsmasq** runs on Linux and is included by default with dd_wrt
Questions?