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

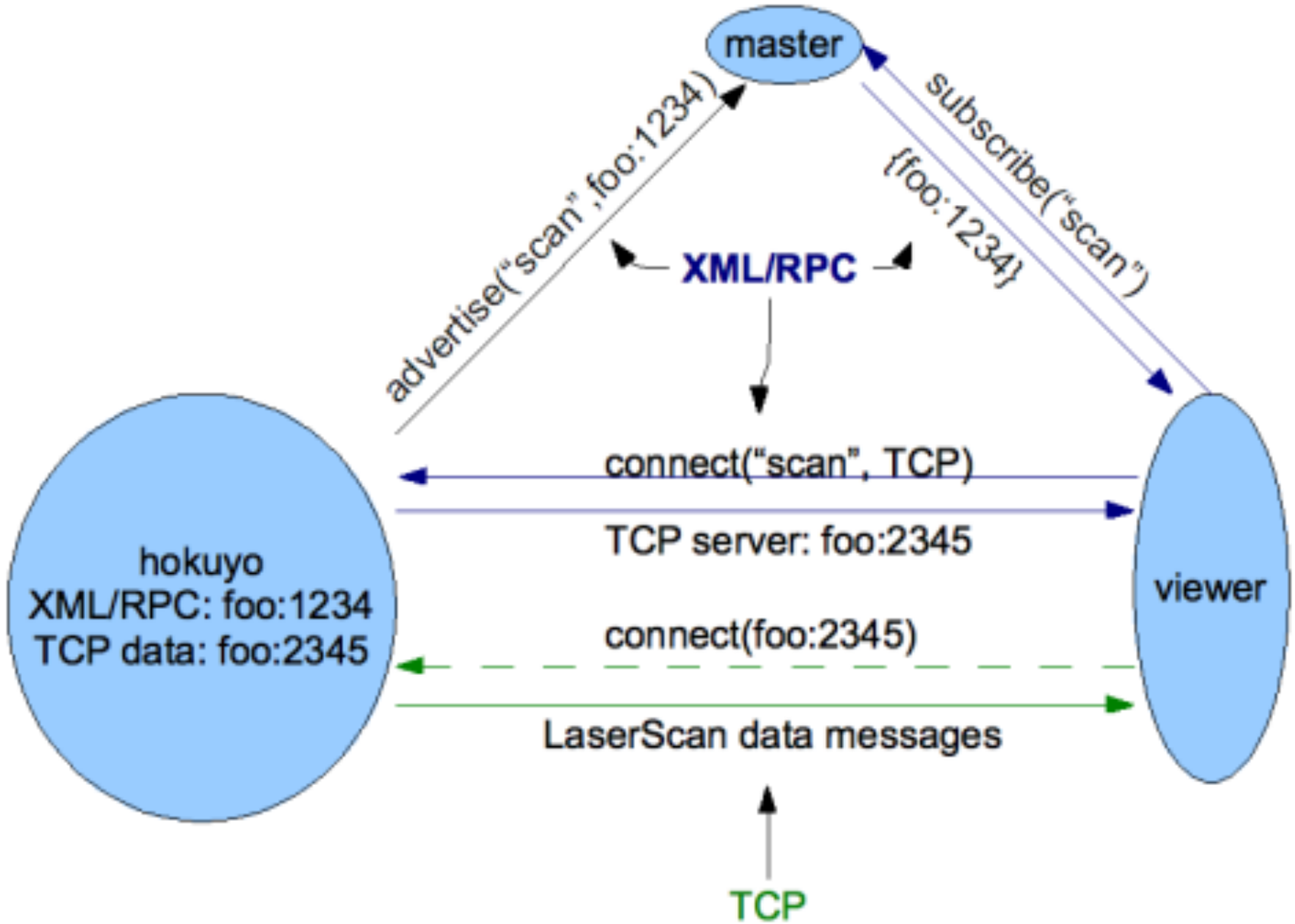
The Basics

- 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

```
$ 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$ rosnode ping B
  rosnode: 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 brige, 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?