CS 378: Autonomous Intelligent Robotics (FRI)

Dr. Todd Hester

Are there any questions?

Logistics

- CS mentoring in Kinsolving and Jester dining halls
- First homework assignment (due class time Thursday)
- Talks Friday
  - Dr. Mohan Sridharan
  - Towards Autonomy in Human-Robot Collaboration
    - 11 am, ACES 2.402
  - Integrating Answer Set Programming and Probabilistic Planning on Robots
    - 3 pm, ACES 2.402

Dr. Xiaofeng Ren's talk

- Summary
- Can we apply it to our project?
- What won't will apply to our project?

Today

Robot Operating System (ROS)

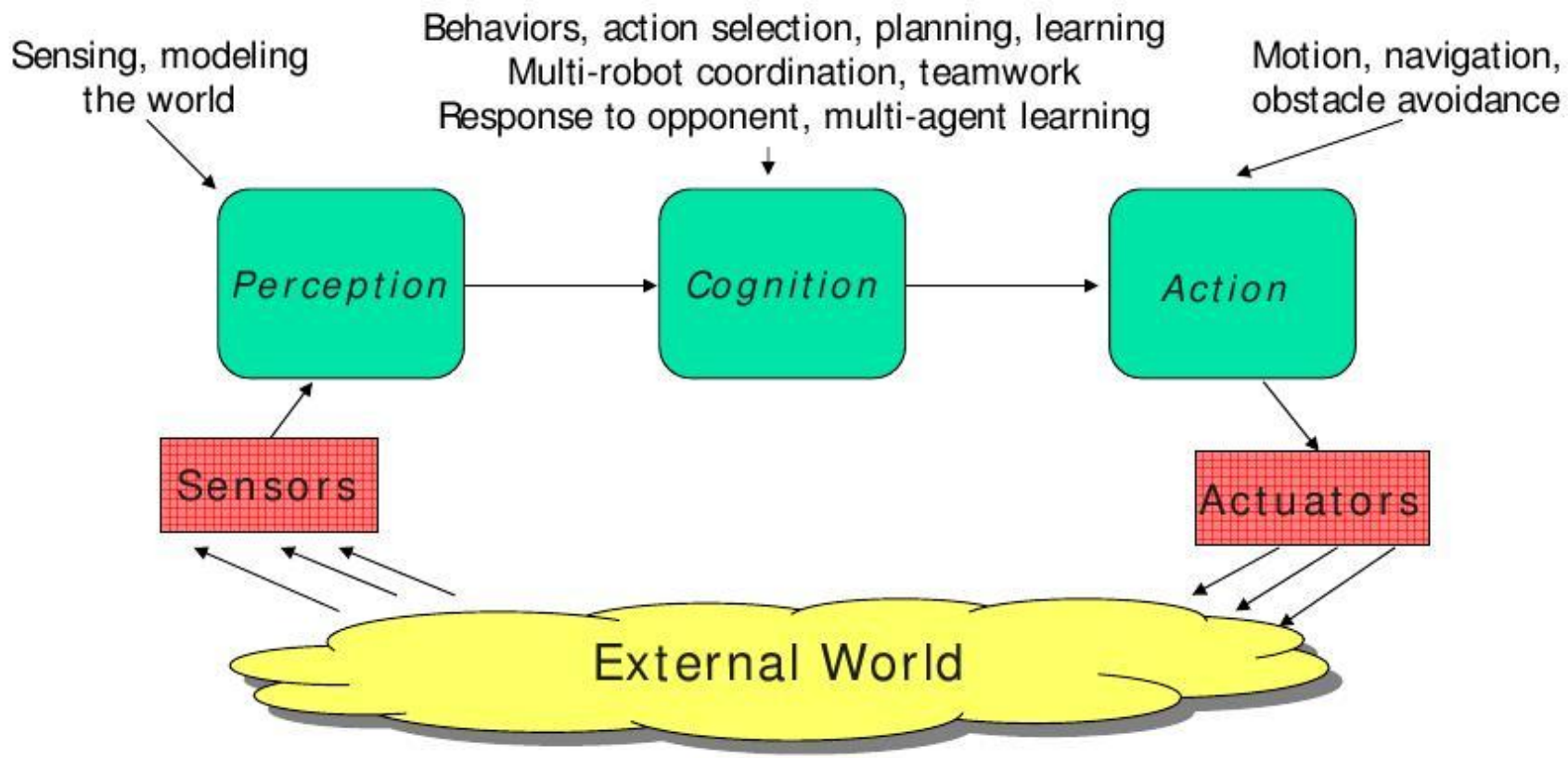
Readings

- High level overview
- Advantages of using ROS?
- Disadvantages of using ROS?

ROS

(adapted from slides by Prof. Chad Jenkins and Piyush Khandelwal)

Intelligent Complete Robot



[slide by Manuela Veloso]

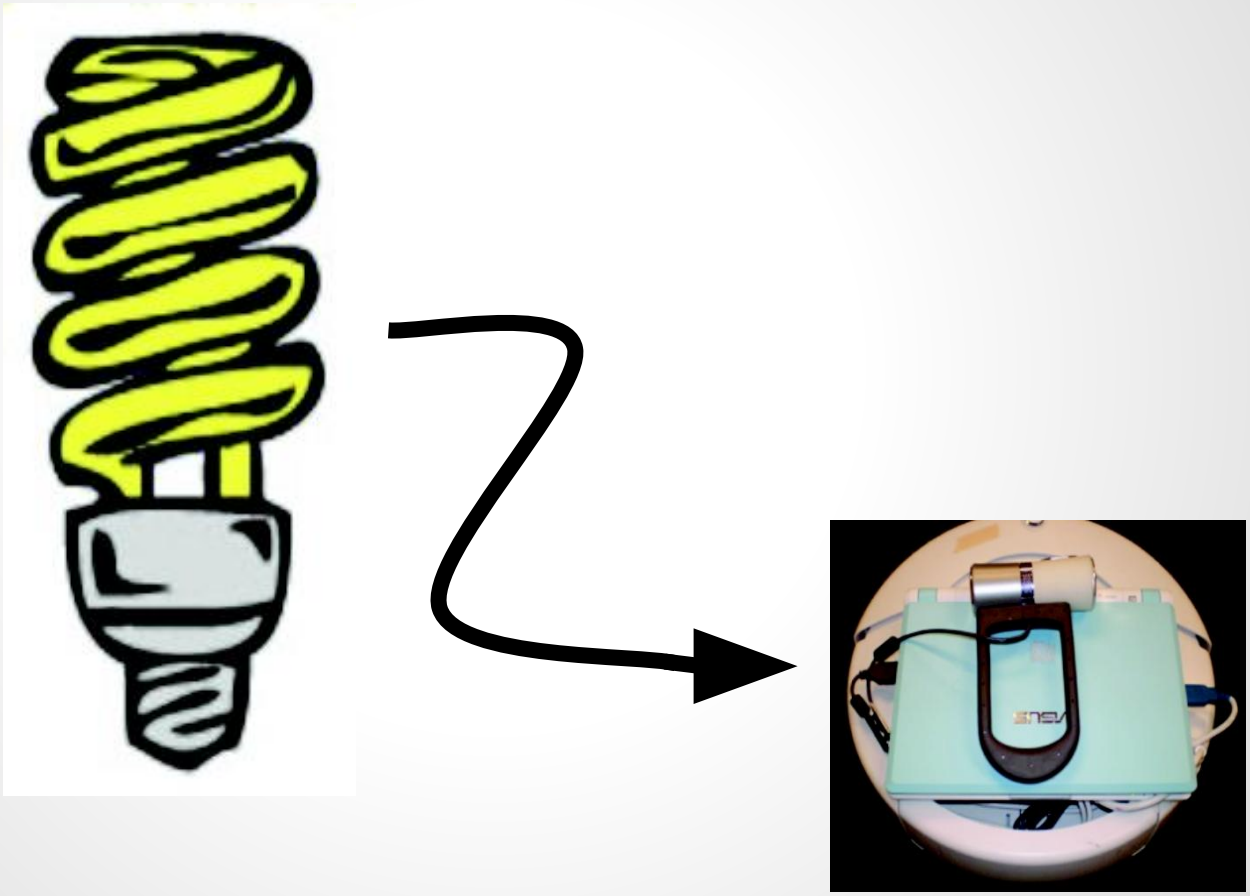
Example: iRobot Create based robot

[adapted from slide by Chad Jenkins]

Software Architecture

- From wikipedia: *"The **software architecture** of a system is the set of structures needed to reason about the system, which comprise software elements, relations among them, and properties of both."*
- Software architecture is important for
  - creating reusable code
  - ensuring portability between different devices and platform
- Important for robotics because
  - Large code-bases
  - Integration of many different and a dynamic set of devices
  - Many different options for a single component

Controlling robots using code



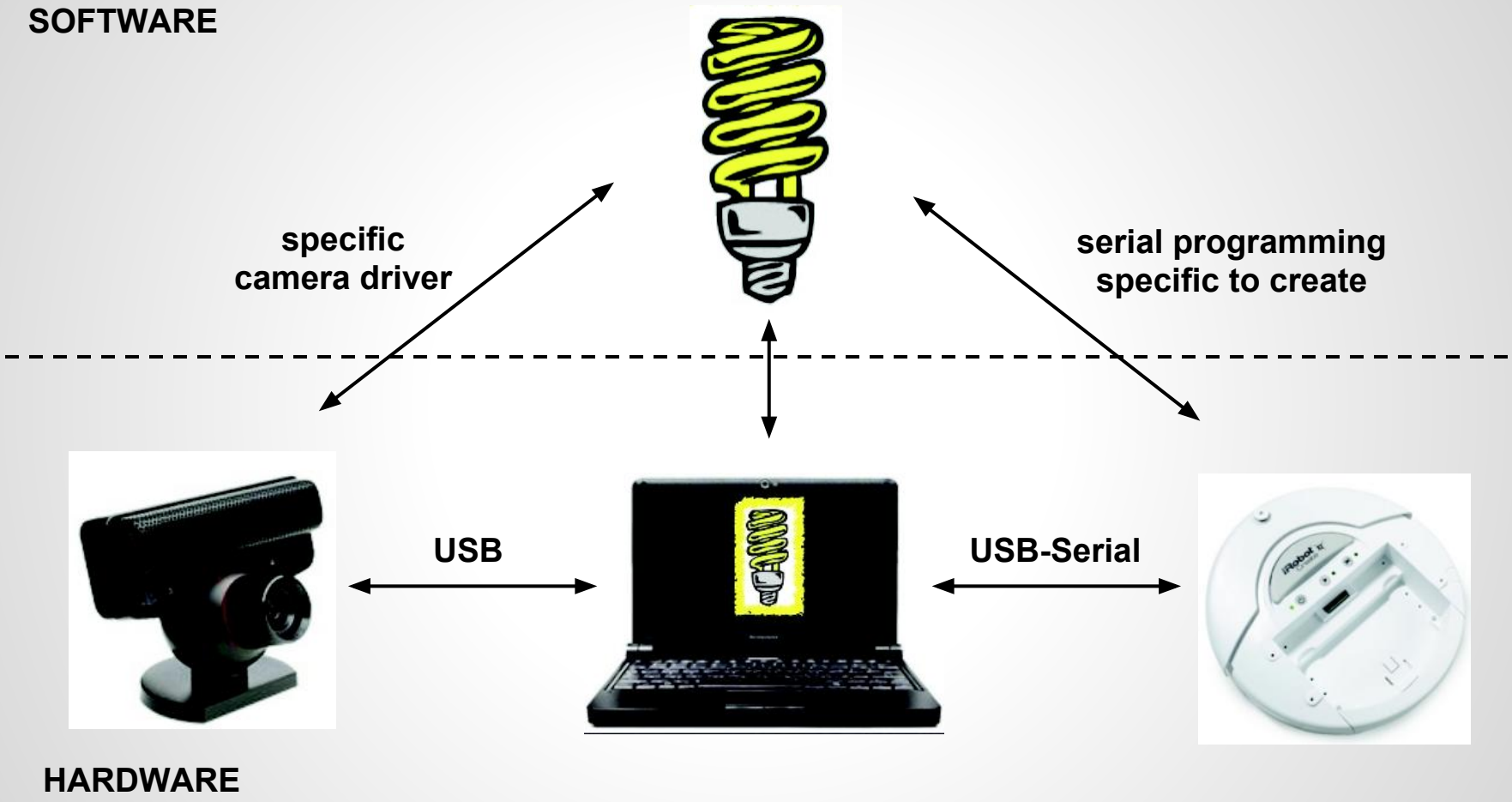
[adapted from slide by Chad Jenkins]

Straightforward approach

- Just write and compile a program to perform robot's "cognitive" functions
- This program will include
  - Code to interface with the camera and the iRobot Create
  - Code to understand the images and the environment and control the Create
- Once implemented, the system works well and efficiently

[adapted from slide by Chad Jenkins]

Straightforward approach



- However this approach suffers from a problem. Any ideas?

[adapted from slide by Chad Jenkins]

An example problem...

- After implementing my program, I realized the create is too slow (0.5 m/s).
- How easy it is to use a segway robot instead (1.7 m/s)?

+

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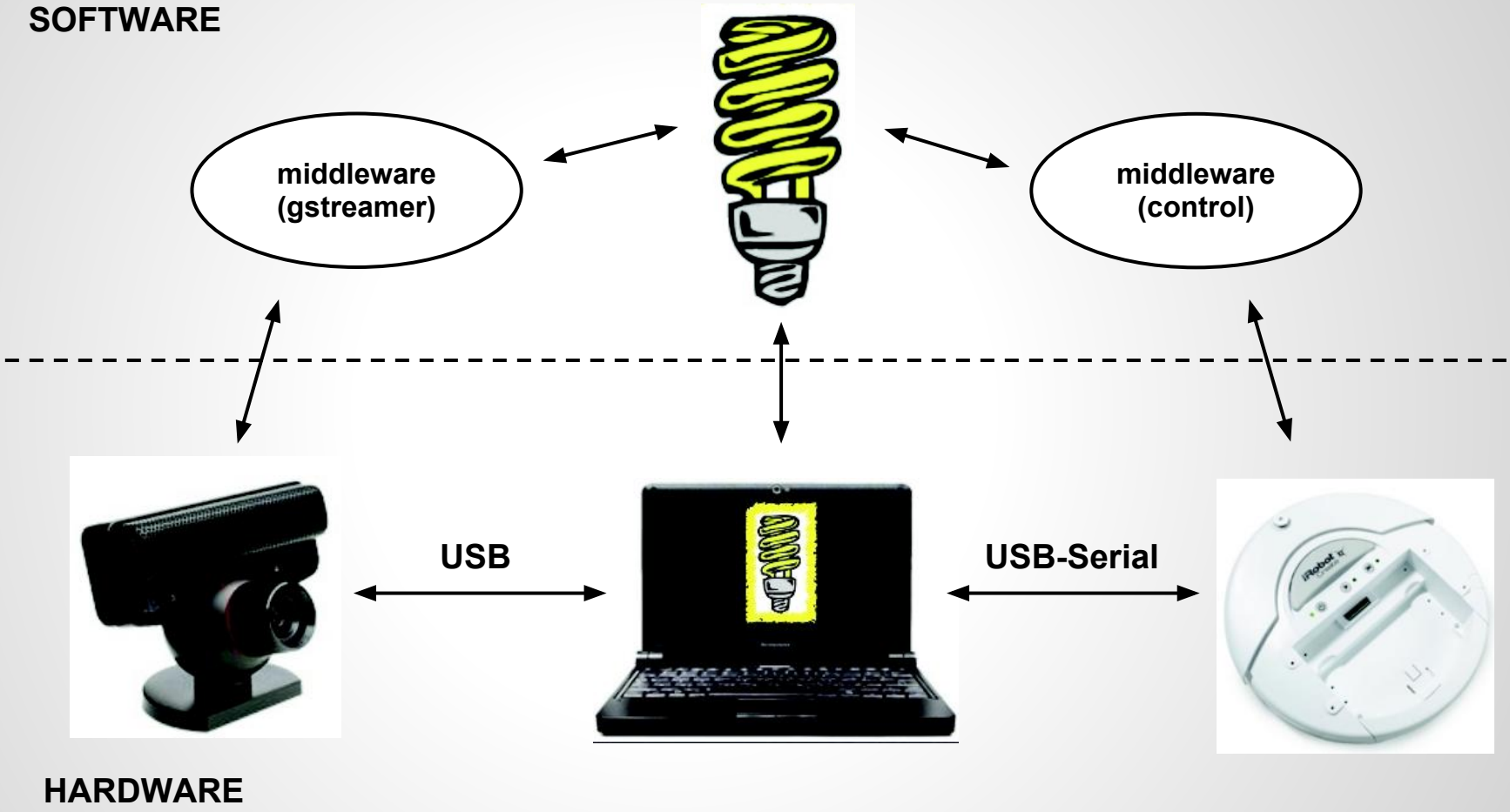
Could I have implemented my code differently to make this transition easier?

Enter robot middleware

- Provide an abstraction layer and drivers between computation and embodiment.
- This is the similar to how hardware abstraction allows your program to work independent of the actual hardware.
  - i.e. the hardware abstraction layer in the operating system.
- Using a middleware package might seem a subtle difference right now, but it is a fundamentally different approach to developing robot applications. Lets look at an example.

[adapted from slide by Chad Jenkins]

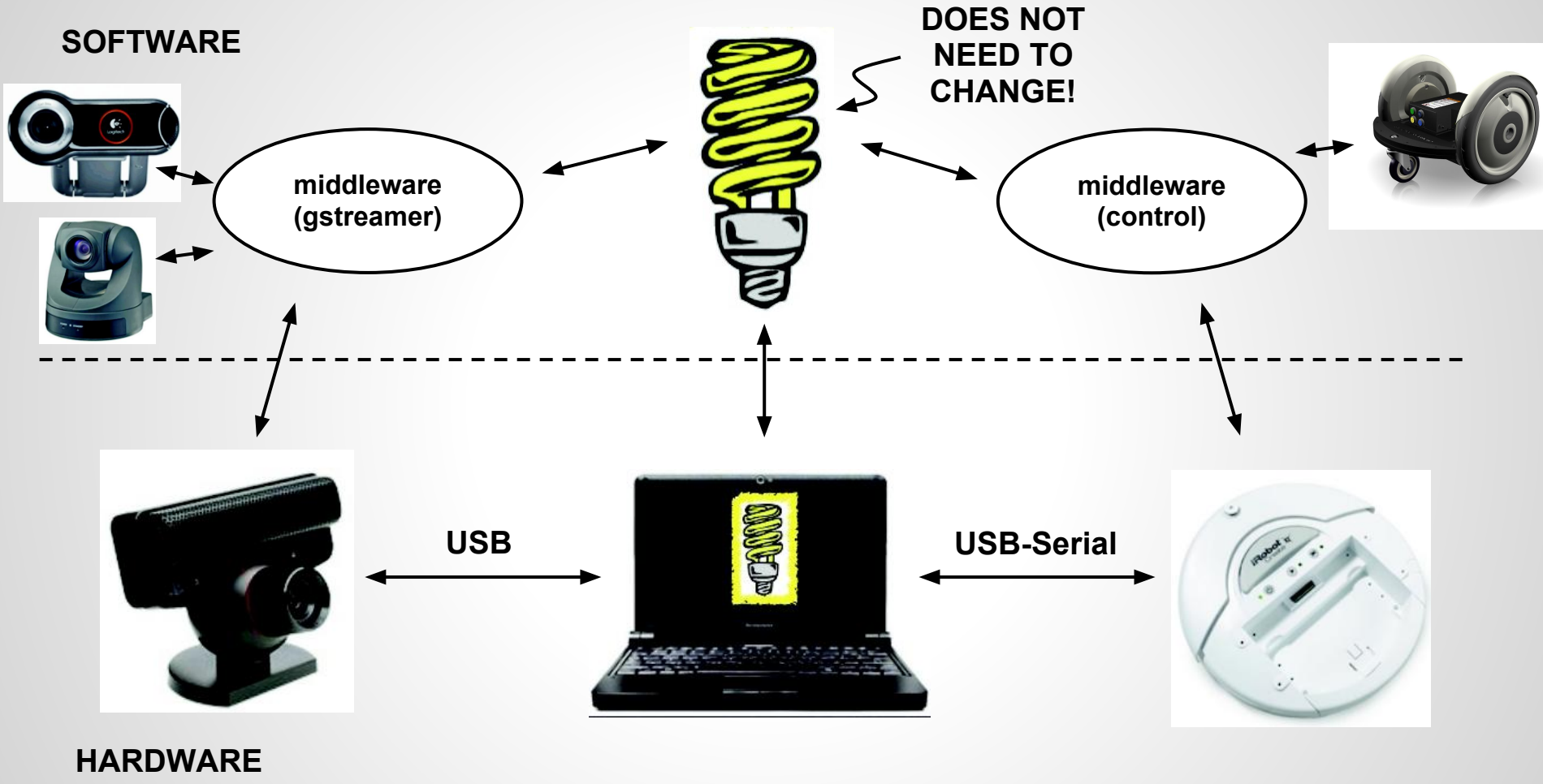
Using robot middleware



- Looks about the same. So whats the advantage?

[adapted from slide by Chad Jenkins]

Using robot middleware

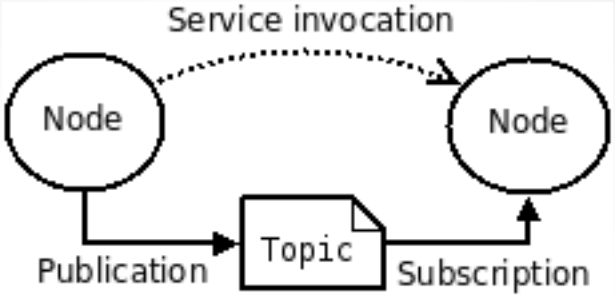


[adapted from slide by Chad Jenkins]

The advantages

- Reusability
  - Reuse existing drivers and code written for other robots, platforms and research projects.
- Portability
  - Easier to switch to another robotic platform.
- Easier to expand functionality

ROS (Robot Operating System)



- A very popular robot middleware package
- Peer-to-peer architecture among nodes over a network
- Robot functionality split over multiple nodes (processes)
- Nodes subscribe to and publish messages on "topics"
  - ROS Master runs topic registry
- Topics are named channels over which messages are exchanged

[adapted from slide by Chad Jenkins]
[image from http://www.ros.org/wiki/ROS/Concepts]

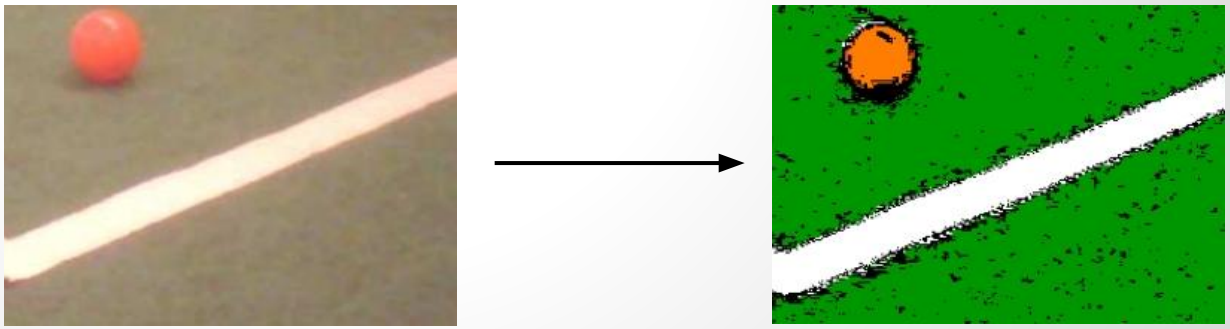
Robot Example

Let's say we have a camera, a laptop, and a create, and we want to move the robot based on detected objects in the camera image.

- What nodes might we use?
- What messages would they send?

How it works - Create example

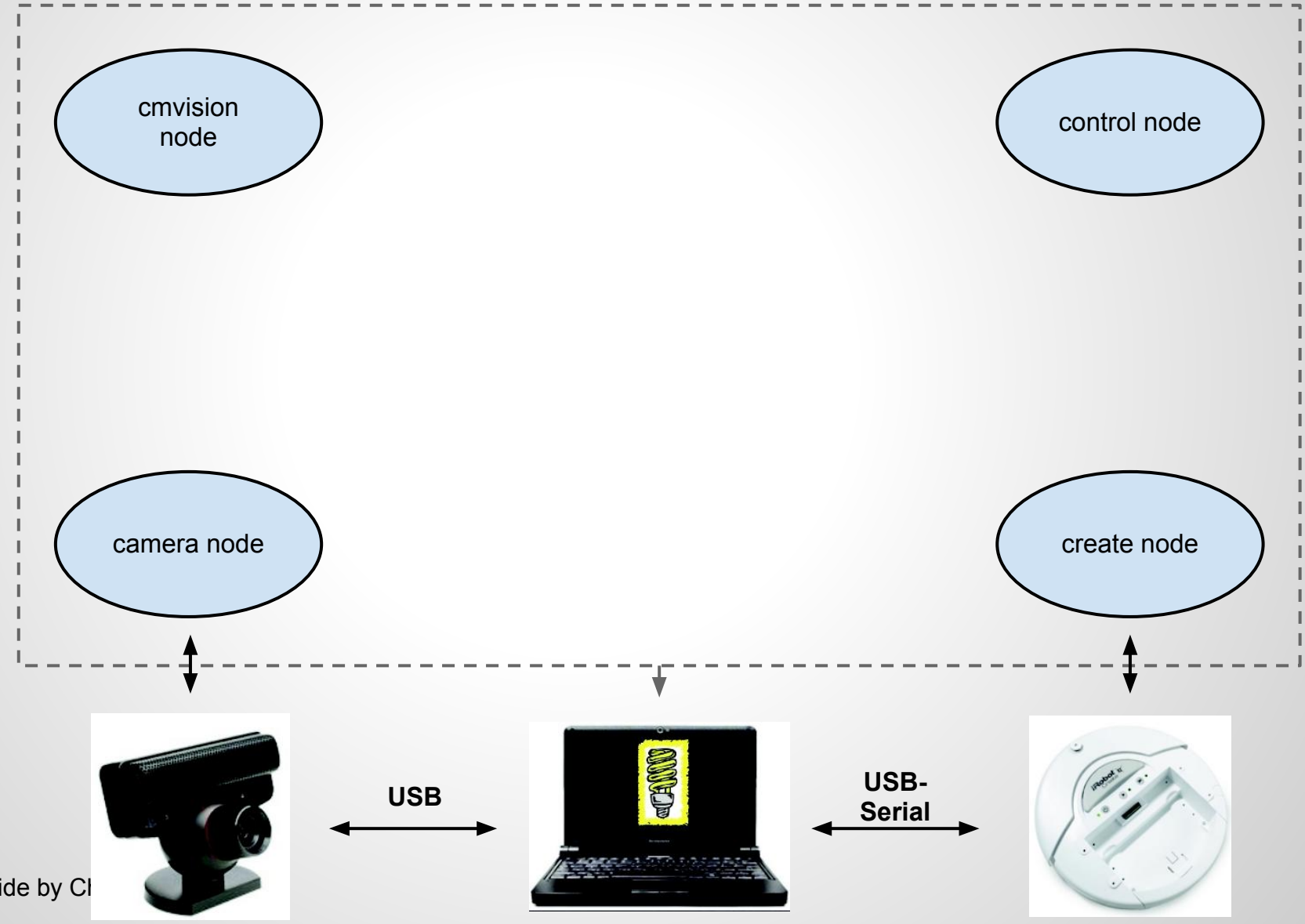
- Lets say we split up the code into 4 functional components
  - Camera Driver - produces images from the camera
  - Create Driver - accepts forward and angular velocity and makes the Create move
  - Blobfinder node (cmvision) - takes an image and returns the positions of different colored blobs on the screen



  - Control node - takes the position of the orange blob and calculates the velocities required to reach it.

[adapted from slide by Chad Jenkins]

How it works



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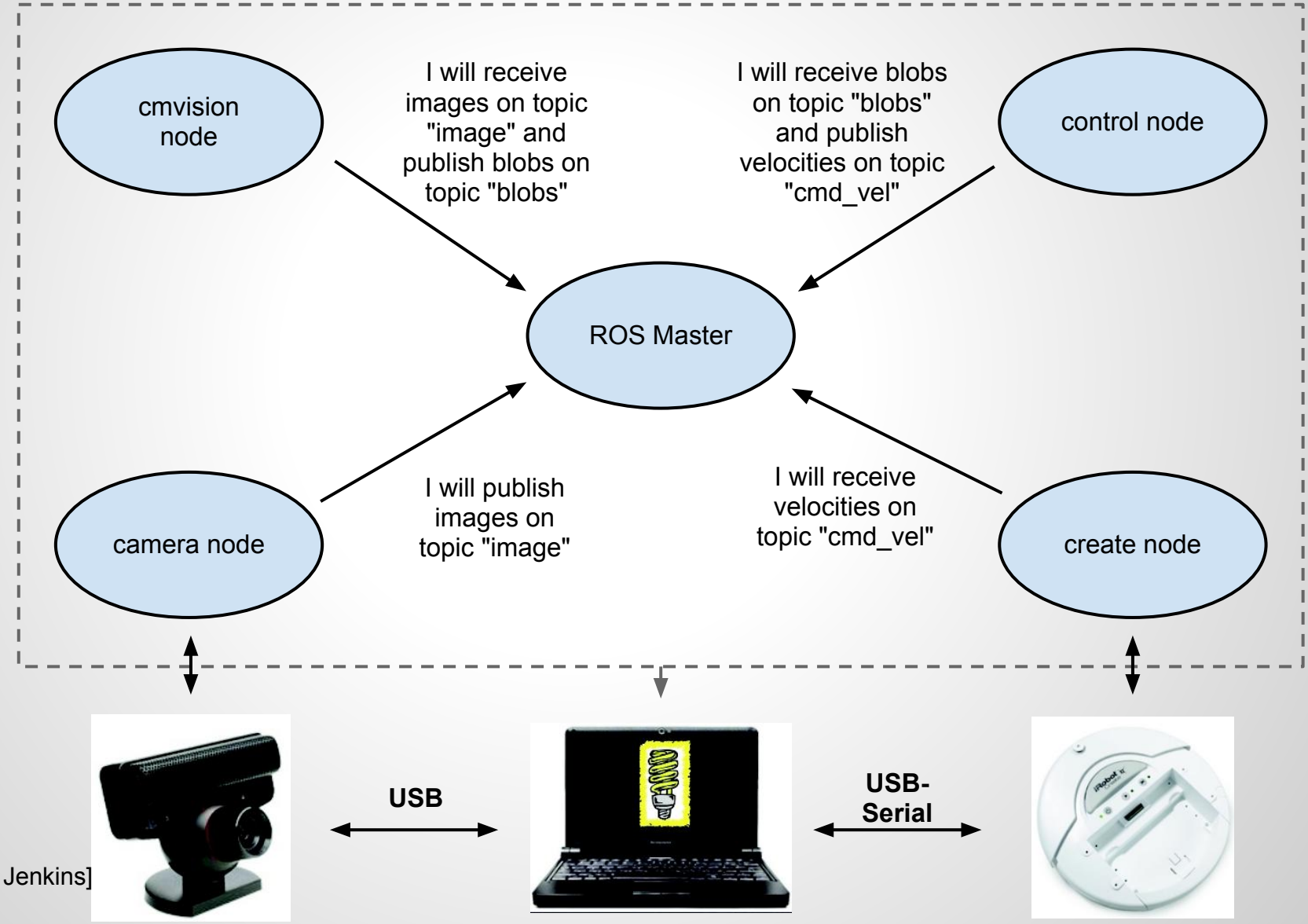

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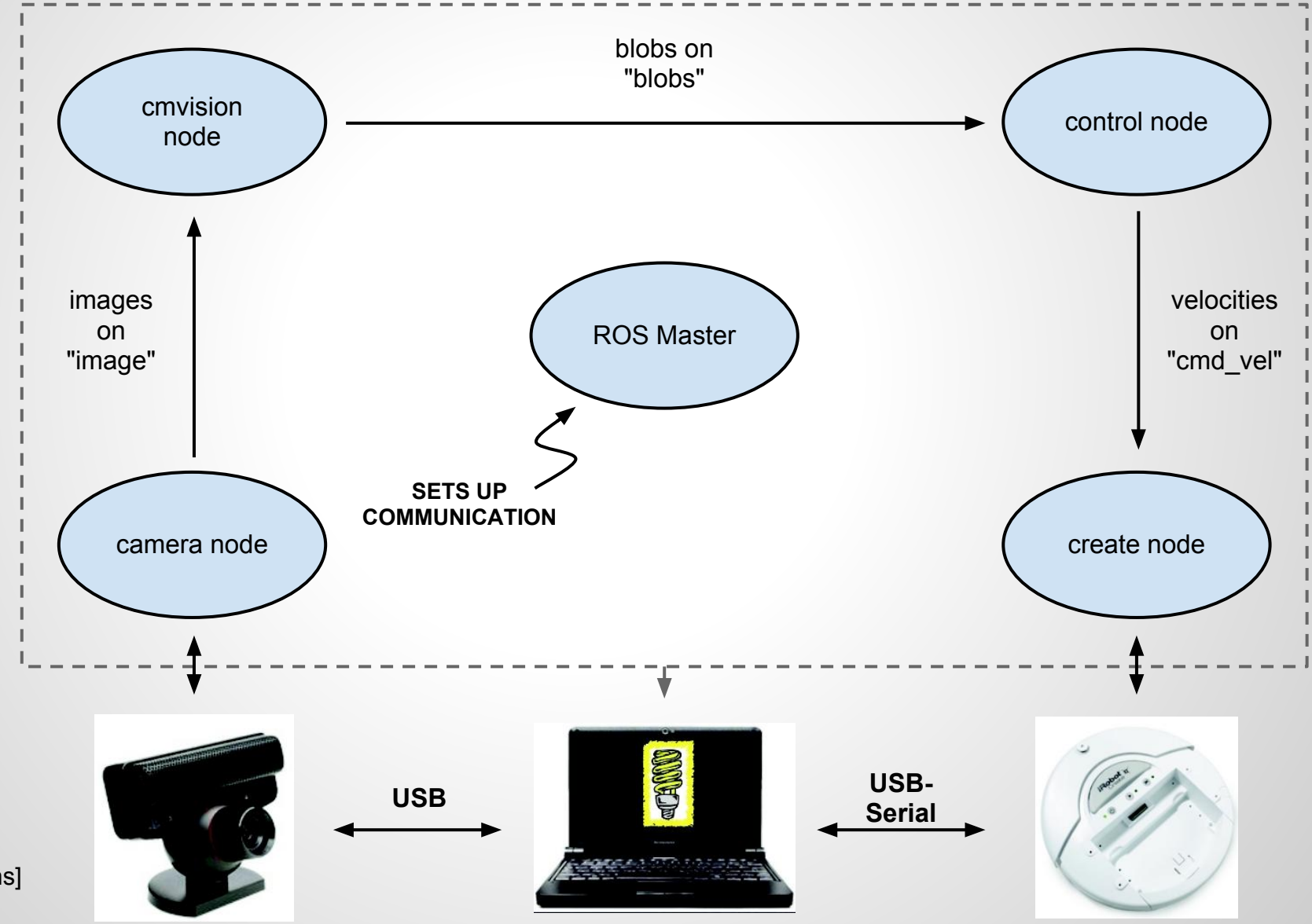
How it works



e by Chad Jenkins]

How it works

- These message formats for inter-node communication are *well defined*. We'll see more of these in upcoming weeks
- All this communication is done over TCP or UDP. This allows one of your nodes to be in China if you want.
- In many cases, all these nodes are running on a single machine

[adapted from slide by Chad Jenkins]

ROS Nodes

- A *node* is a process that performs some computation.
- Typically we try to divide the entire software functionality into different modules - each one is run over a single or multiple nodes.
- Nodes are combined together into a graph and communicate with one another using streaming topics, RPC services, and the Parameter Server
- These nodes are meant to operate at a fine-grained scale; a robot control system will usually comprise many nodes

[http://www.ros.org/wiki/Nodes]

ROS Topics

- Topics are named buses over which nodes exchange messages
- Topics have anonymous publish/subscribe semantics - A node does not care which node published the data it receives or which one subscribes to the data it publishes
- There can be multiple publishers and subscribers to a topic
  - It is easy to understand multiple subscribers
  - Can't think of a reason for multiple publishers
- Each topic is strongly typed by the ROS message it transports
- Transport is done using TCP *or* UDP

ROS Messages

- Nodes communicate with each other by publishing *messages* to topics.
- A message is a simple data structure, comprising typed fields. You can take a look at some basic types here
  - std_msgs/Bool
  - std_msgs/Int32
  - std_msgs/String
  - std_msgs/Empty (huh?)
- Messages may also contain a special field called header which gives a *timestamp* and *frame of reference*

[http://www.ros.org/wiki/Messages]

ROS Naming

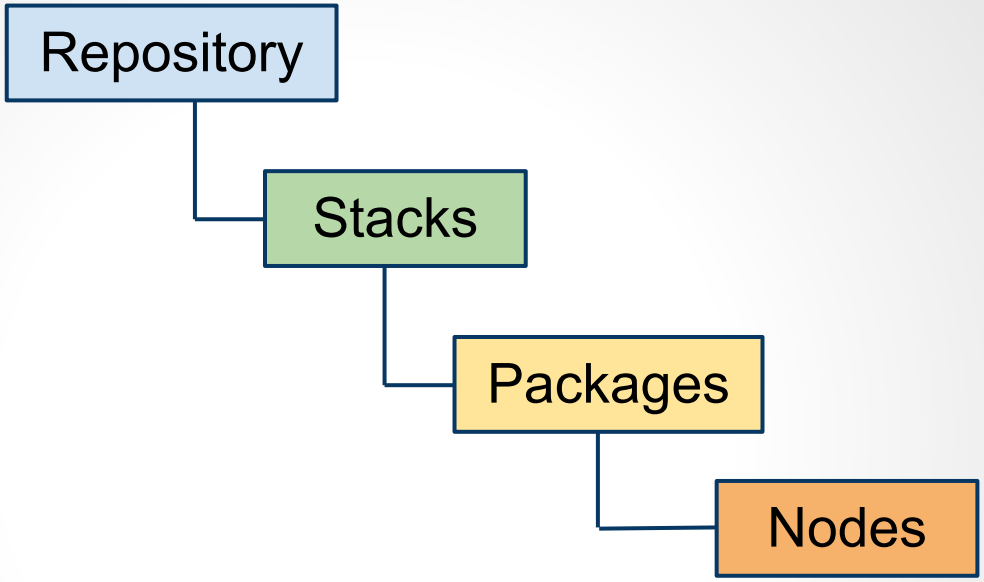
- Subscription is to particular named topic
- No knowledge of actual node you are connecting to

- Also compiling or running packages
  - rosmake
  - rosrun
  - roscd
  - roslaunch
- name of the Package that the resource is in plus the name of the resource
- rosrun segbot_gazebo segbot_mobile_base.launch

Open-Source Code / Collaboration

http://www.ros.org/wiki/Repositories

ROS code hierarchy



- Repository: Contains all the code from a particular development group (We have 3 repositories from utexas)
- Stack: Groups all code on a particular subject / device
- Packages: Separate modules that provide different services
- Nodes: Executables that exist in each model (You have seen this already)

ROS command line tools

- The best way to review the command line tools is through the ROS CheatSheet

ROS: Goals

Main goals of ROS

- Provide a robotics platform designed for code *reuse*
- Provide a code and file structure for easier collaborative development
- Provide a number of tools for visualization and monitoring
- Encourage modularization of drivers and different functional units.

These goals and their benefits will become clearer as this semester progresses

Example 1 - Publisher and Chatter

- The first example is directly from ROS Tutorials
  - http://www.ros.org/wiki/ROS/Tutorials
- I *highly recommend* going through these tutorials on your own time
- We'll take a look at C++ tutorial today (Tutorial 11)
- If you are interested in using ROS in Python go through the Python tutorial (Tutorial 12). The tutorials are fairly similar

First Assignment Due Thursday!