CS 378 - Autonomous Vehicles in Traffic I

Week 2a - Introduction to ROS

(adapted from slides by Prof. Chad Jenkins)

Logistics

- Some updates to class webpage
  - Percentage points for every assignment are now included in the schedule
  - Office hours are up and effective from now on
  - I am adding a couple more sections at the bottom of the webpage with some interesting links
  - I have put up a printable version of the slides as well.

- If you enrolled in the class after Wednesday's class (I think there are 2-3 students), then let me know if you have any questions about the course structure
  - Course structure is available in Week 1 slides

Logistics

- If you have not enrolled to the mailing list cs378-spr12-announce@utlists.utexas.edu, *please do so immediately!*
  - Effective immediately all announcements will be made here
  - Do not sign up for *cs378-spr12-submit*

- Instructions for joining up the mailing list *cs378-spr12-announce* (thanks Kevin!)
  - Go to https://utlists.utexas.edu/sympa/info/cs378-spr12-announce
  - If you've never had a mailing list account before, click the *First login* link in the top left and enter your email address to get a password. Then just log in and subscribe to the list.

Logistics

- In December, a reporter from the UT Alumni magazine approached us to write about this research stream
- I was just told that the story is going to run in their March/April issue
- On Friday they are planning on running a photo-shoot to emphasize the fact that undergrad students are working on the car
- We still need at least 2-3 more students to participate. If any of you are free from 3-4PM (plus some time to get to PRC and back), please let me know after class. I will send an announcement out tonight.

Today

- Autonomous Intelligent Agents
- Importance of software architecture in robotics
- Robot middleware
- What is ROS?

Remember to ask questions wherever necessary!

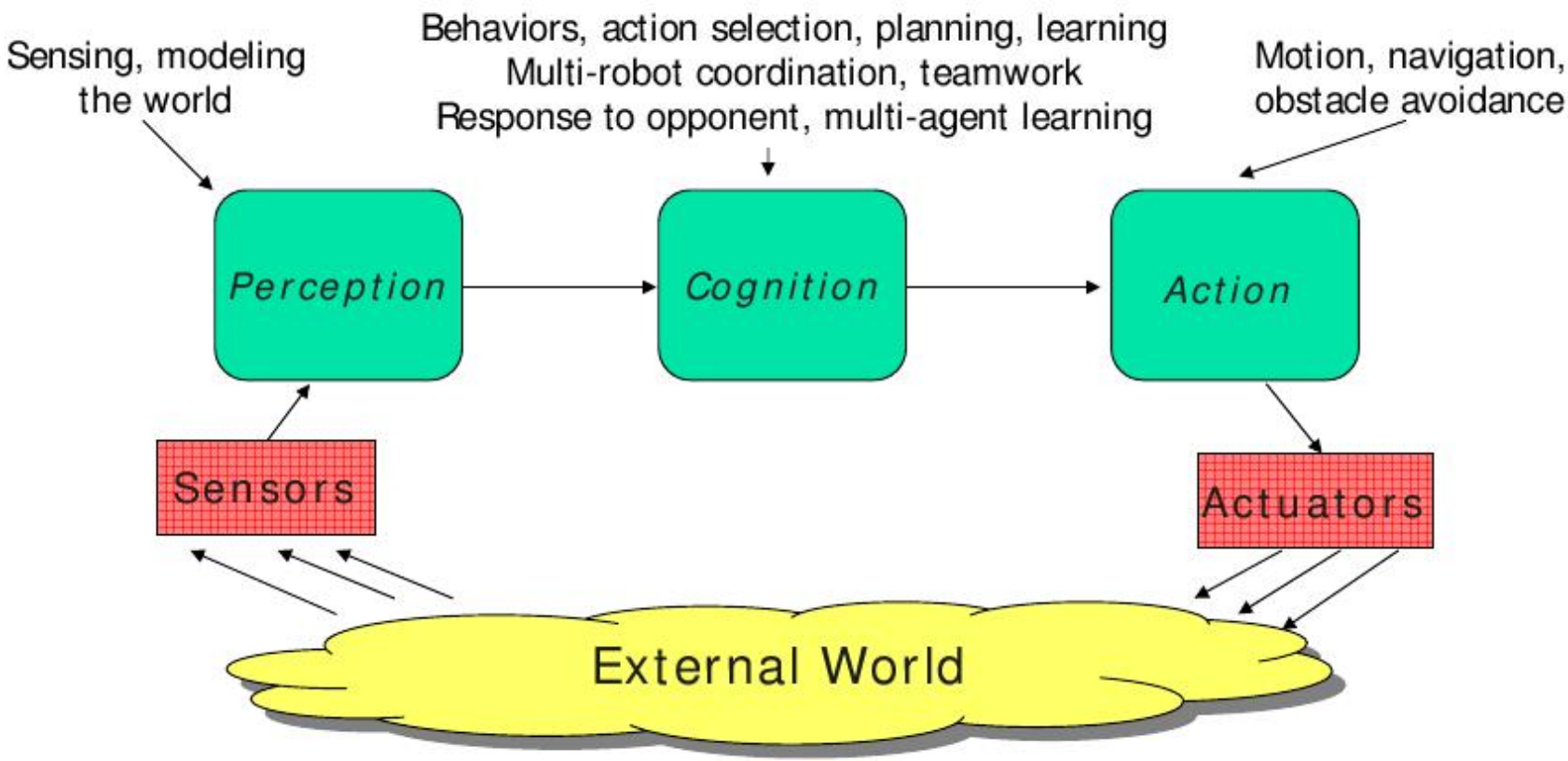
Autonomous Intelligent Agents

- What makes an agent ?
  - They must sense their environment
  - They must decide what action to take (i.e., think)
  - They must act in their environment

- What makes a *complete* agent ?
  - Interact with other agents (Multi-agent Systems)
  - Improve performance from experience (Learning)

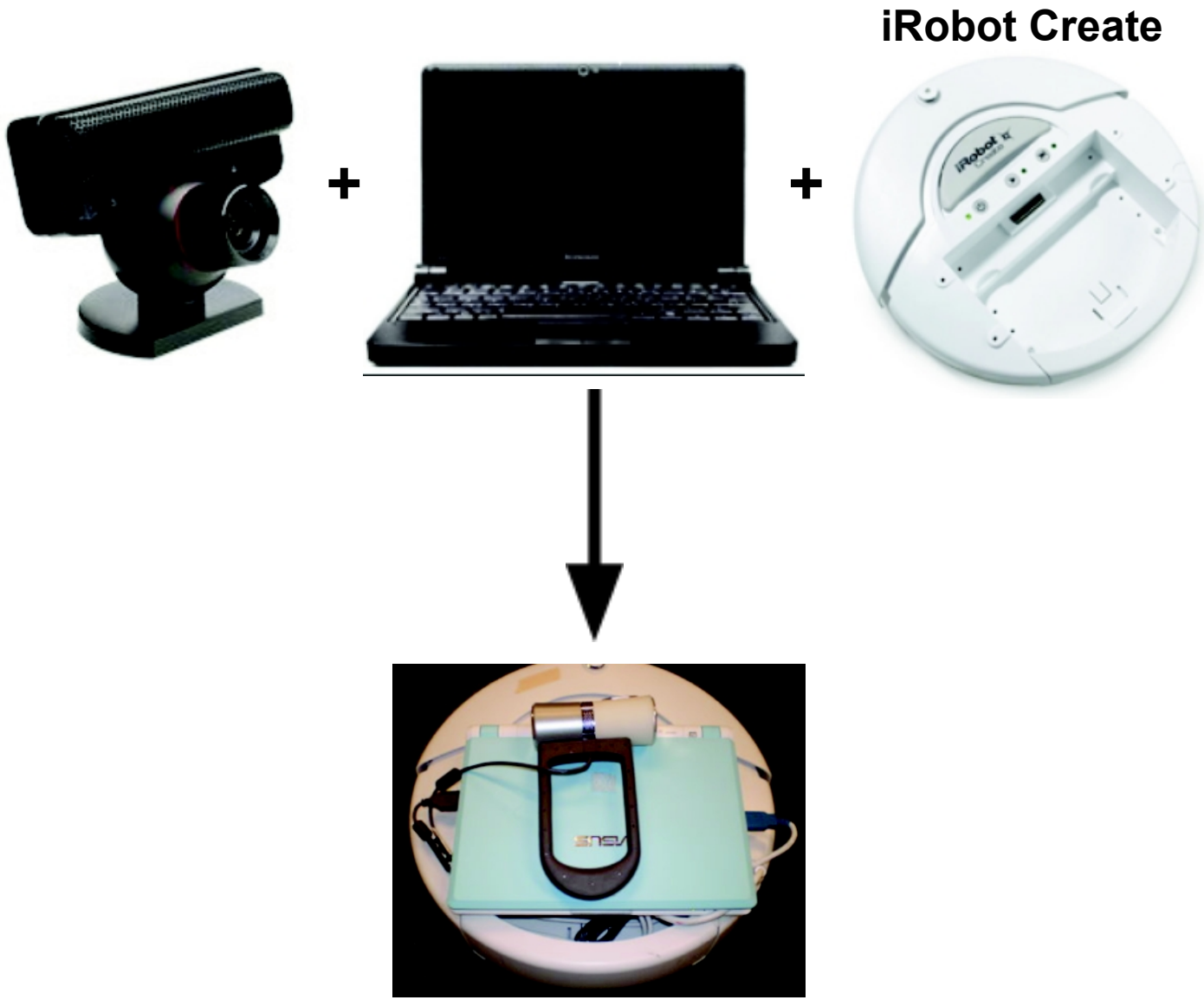
- A robot is an artificial agent that interacts with the physical environment through sensors and actuators.
- What is an example of a non-artificial agent?

Intelligent Complete Robot



[slide by Manuela Veloso]

Example: iRobot Create based robot

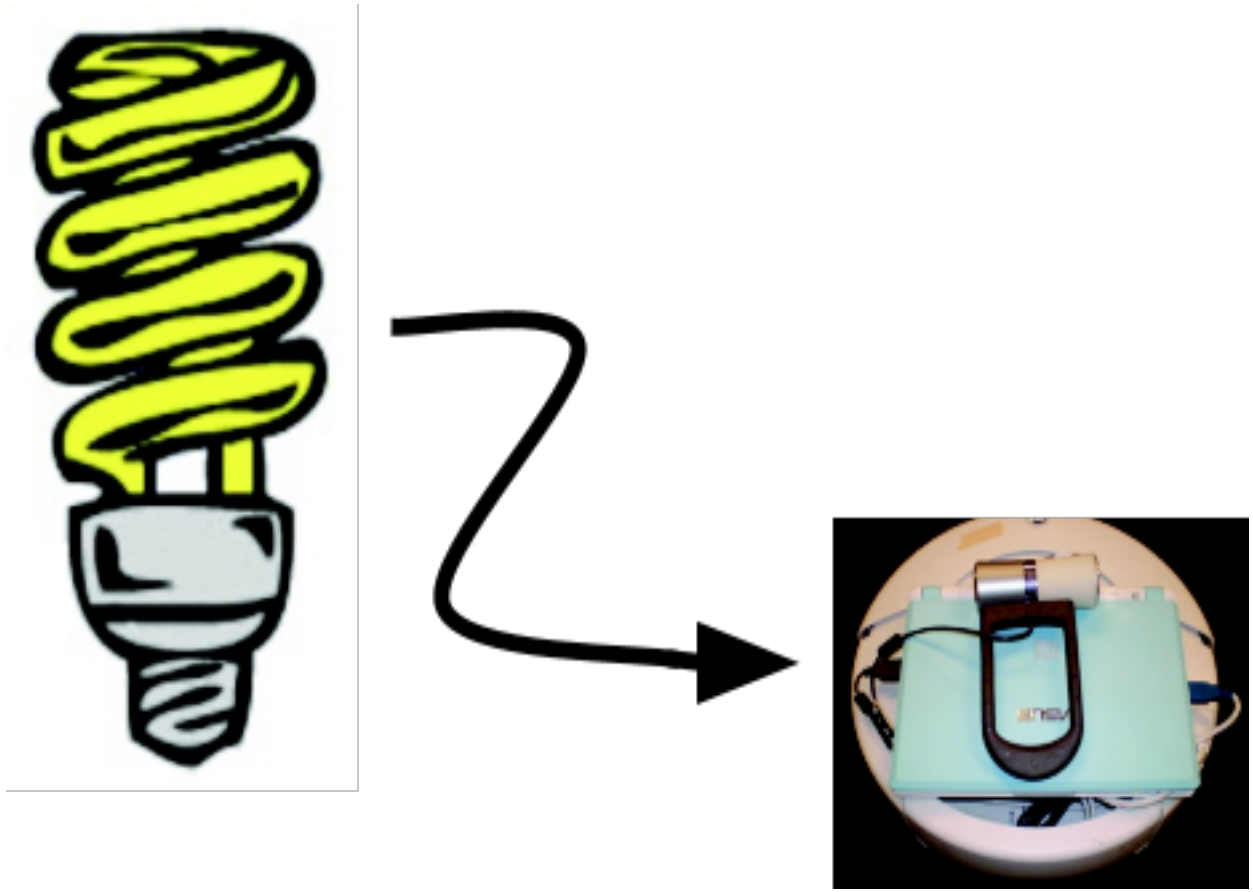


[adapted from slide by Chad Jenkins]

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



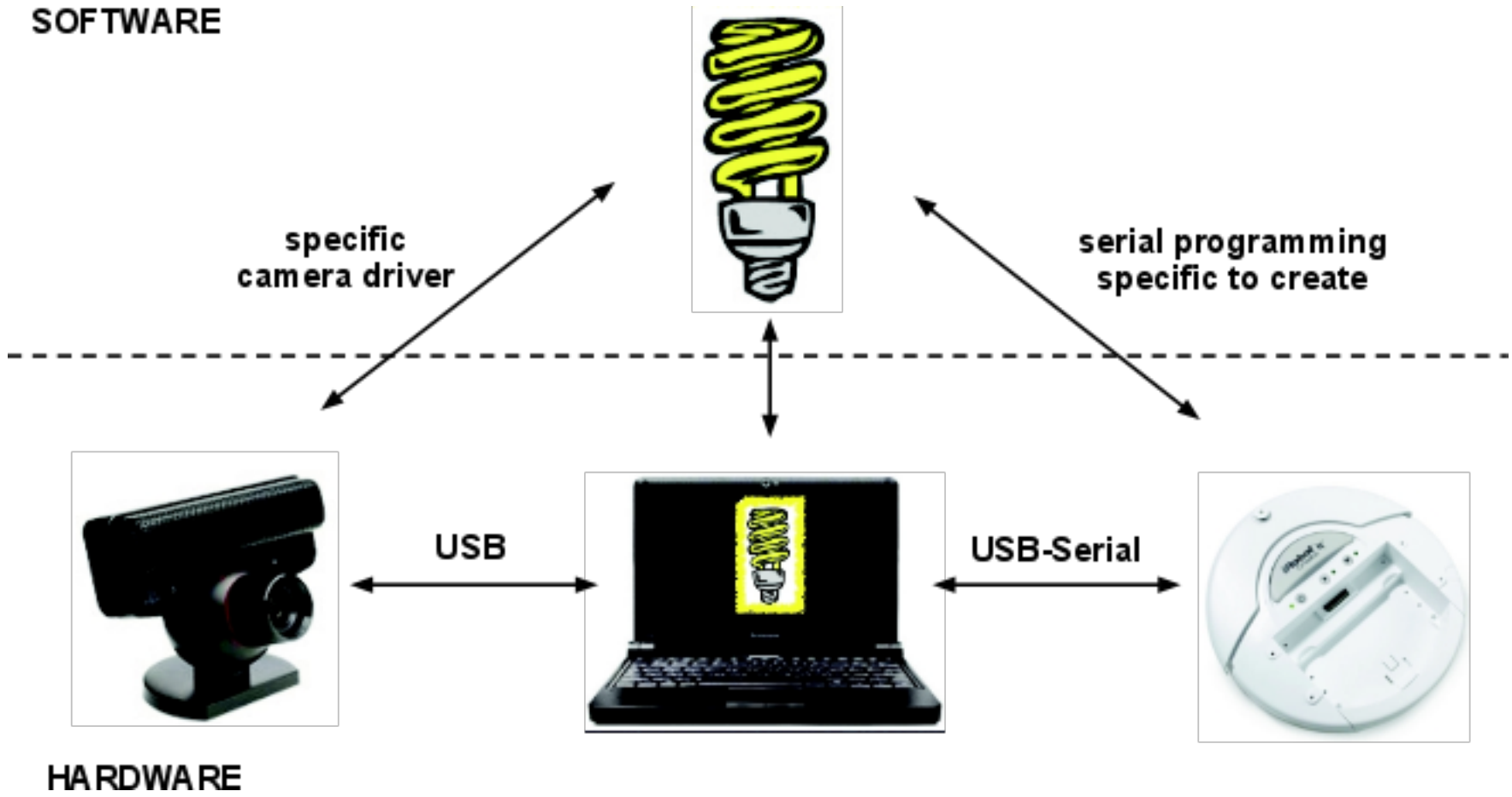
[adapted from slide by Chad Jenkins]

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)?

+

+

Segway RMP50

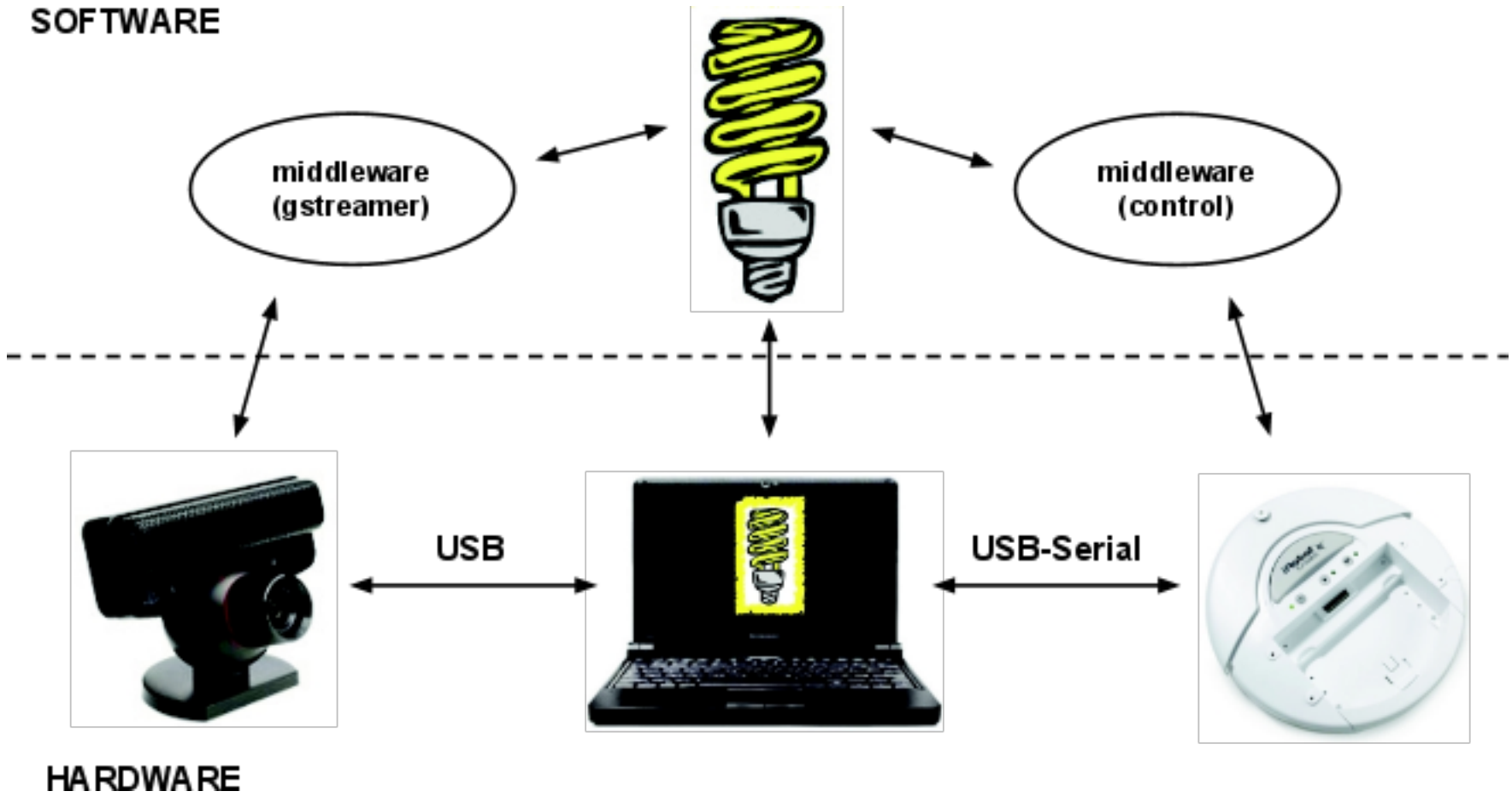
- Could I have implemented my code differently to make this transition easier?

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]

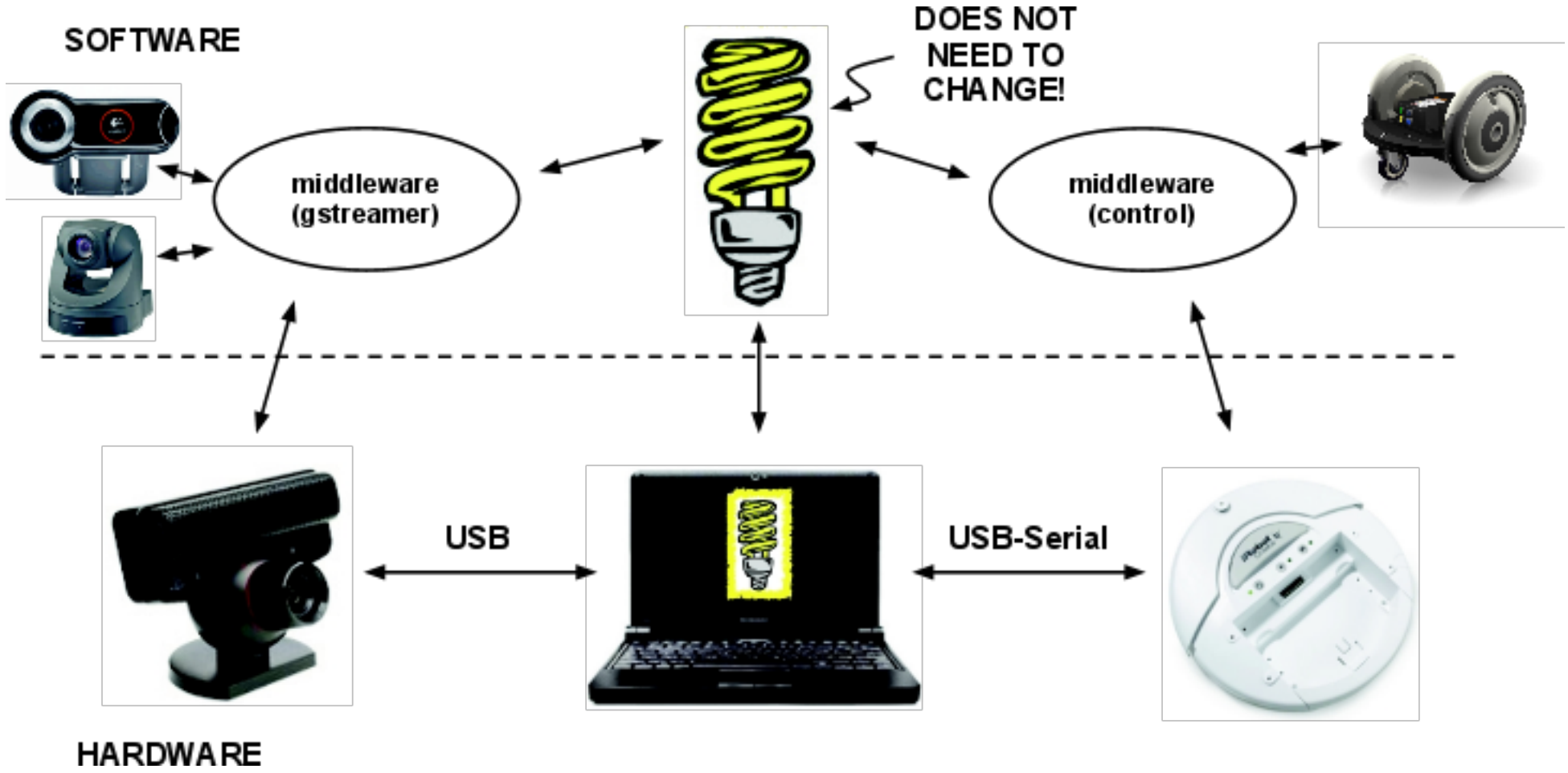
Using robot middleware



- Looks about the same. So whats the advantage?

[adapted from slide by Chad Jenkins]

Using robot middleware



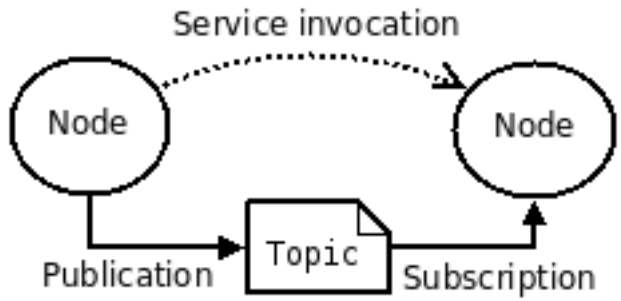
[adapted from slide by Chad Jenkins]

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

[adapted from slide by Chad Jenkins]

ROS (Robot Operating System)

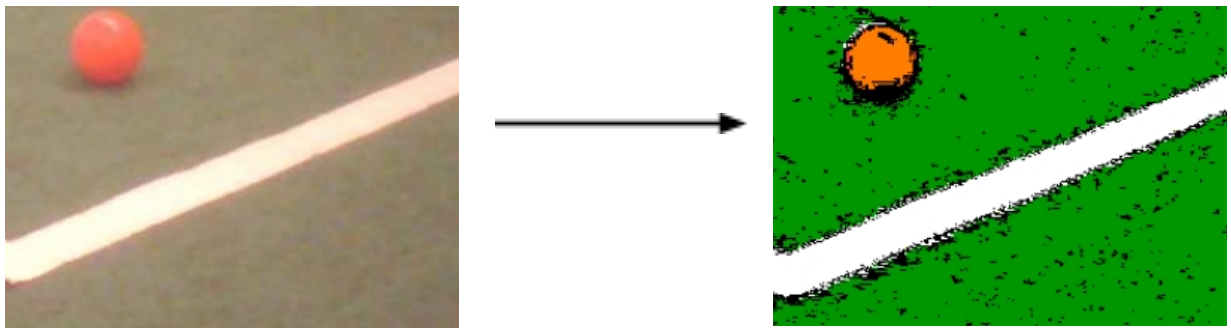


- A very popular robot middleware package
- Peer-to-peer architecture among nodes over a network
- Robot functionality split over multiple nodes (processes)
- Nodes subscribe to and publish messages on "topics"
  - ROS Master runs topic registry
- Topics are named channels over which messages are exchanged
- Later in the semester we'll talk about
  - Nodelets - Each node is no longer its own process (Why?)
  - Services - Request-reply communication

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

How it works - Create example

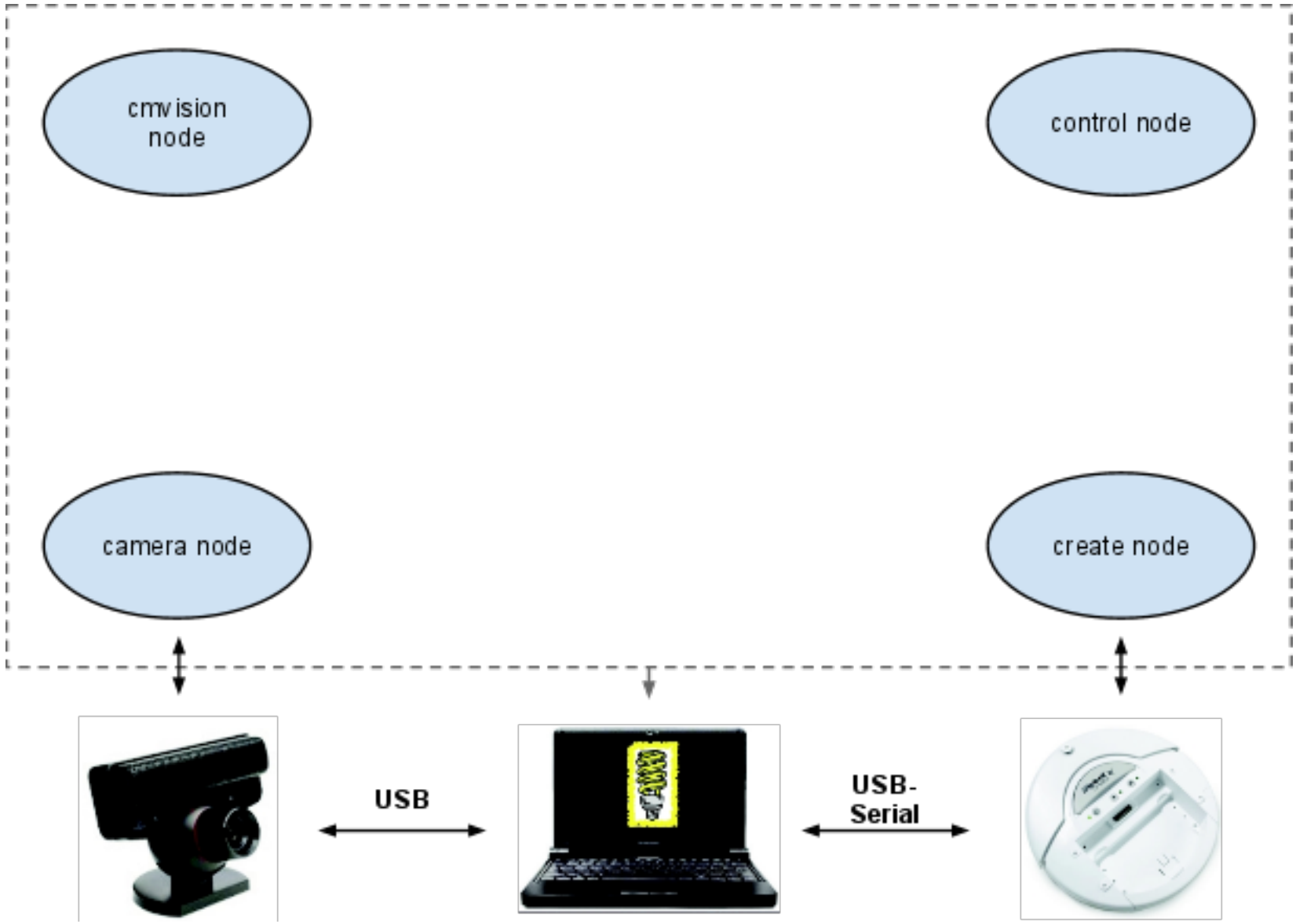
- Lets say we split up the code into 4 functional components
  - Camera Driver - produces images from the camera
  - Create Driver - accepts forward and angular velocity and makes the Create move
  - Blobfinder node (cmvision) - takes an image and returns the positions of different colored blobs on the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



[adapted from slide by Chad Jenkins]

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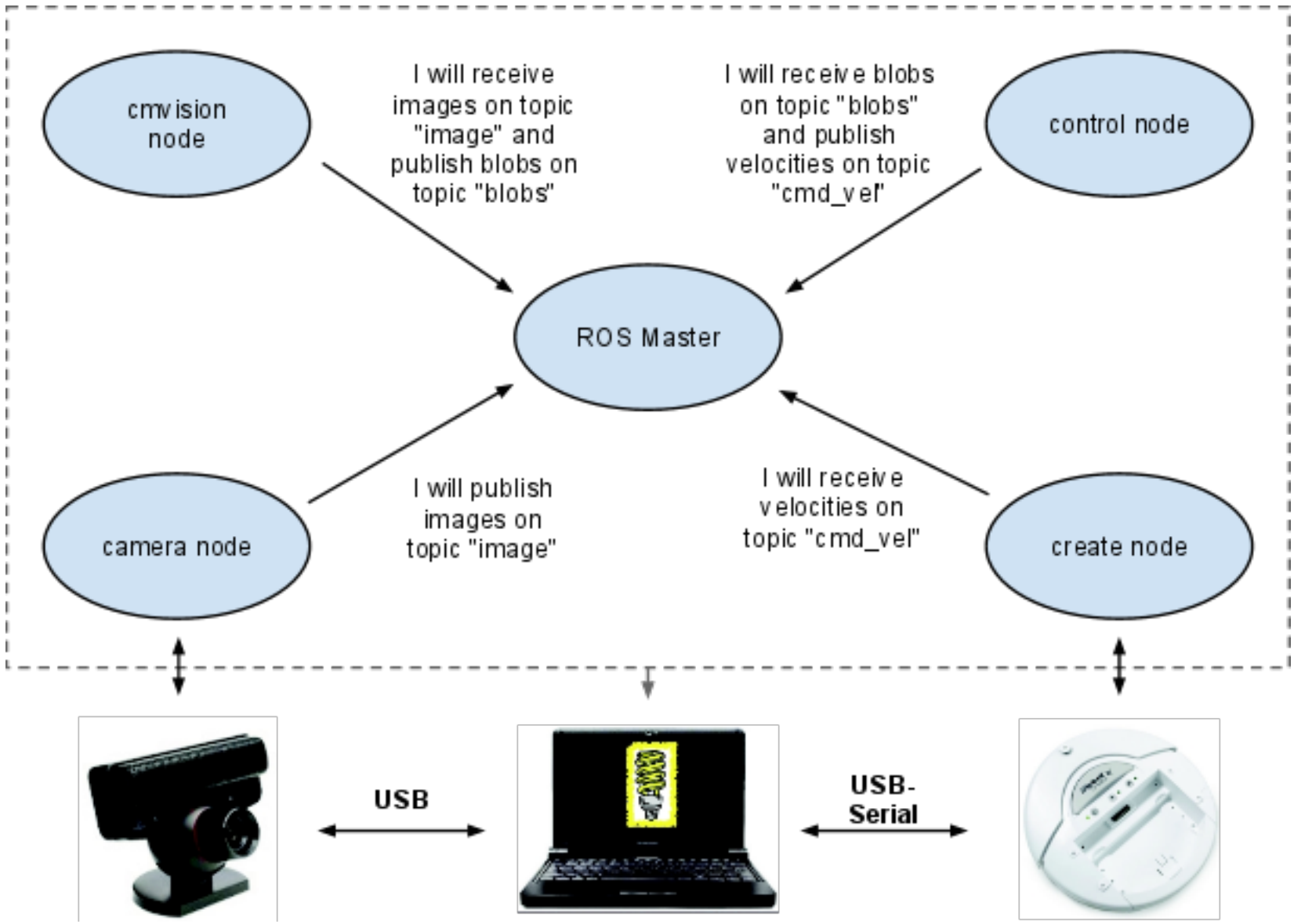
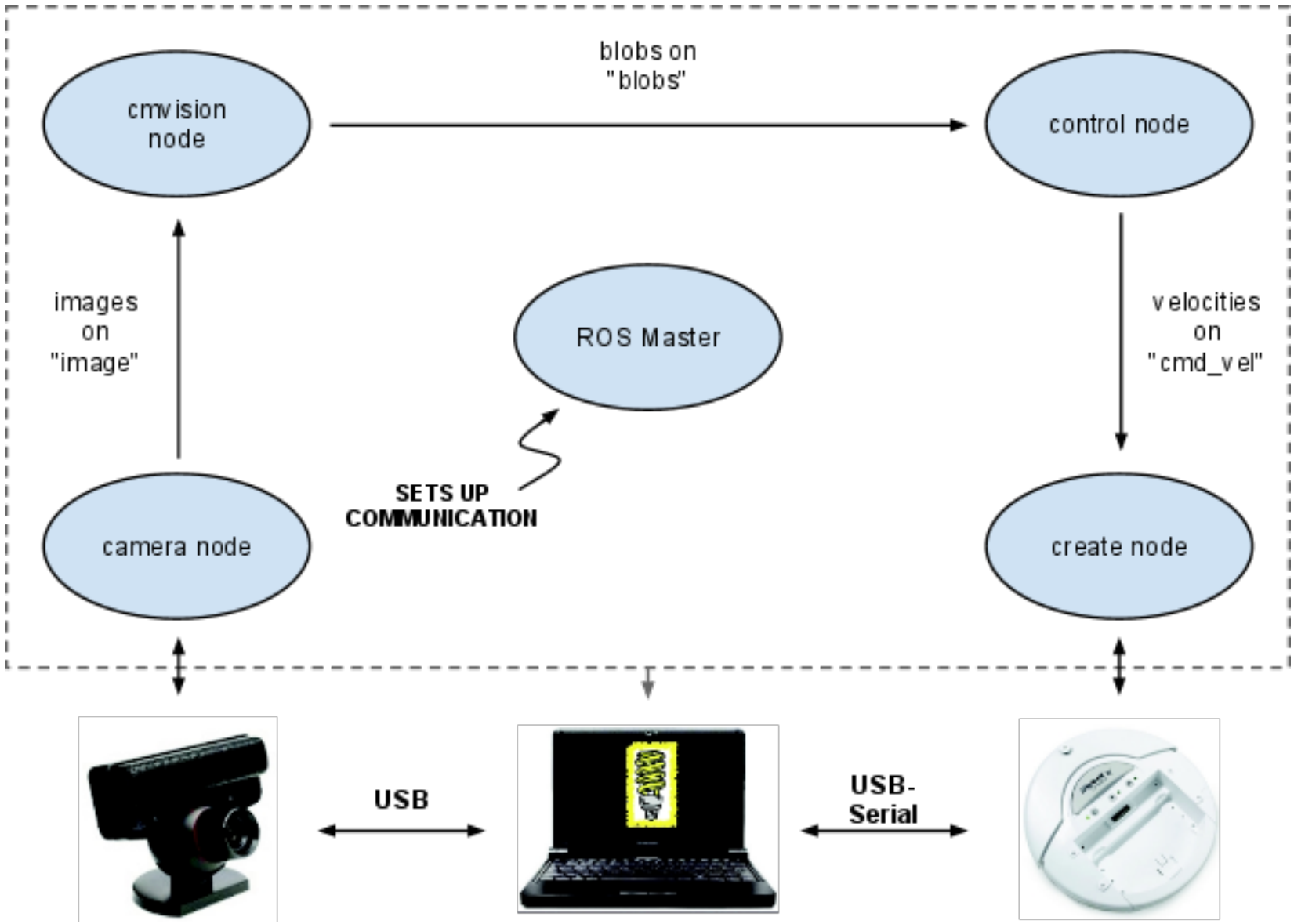


[adapted from slide by Chad Jenkins]

How it works



[adapted from slide by Chad Jenkins]

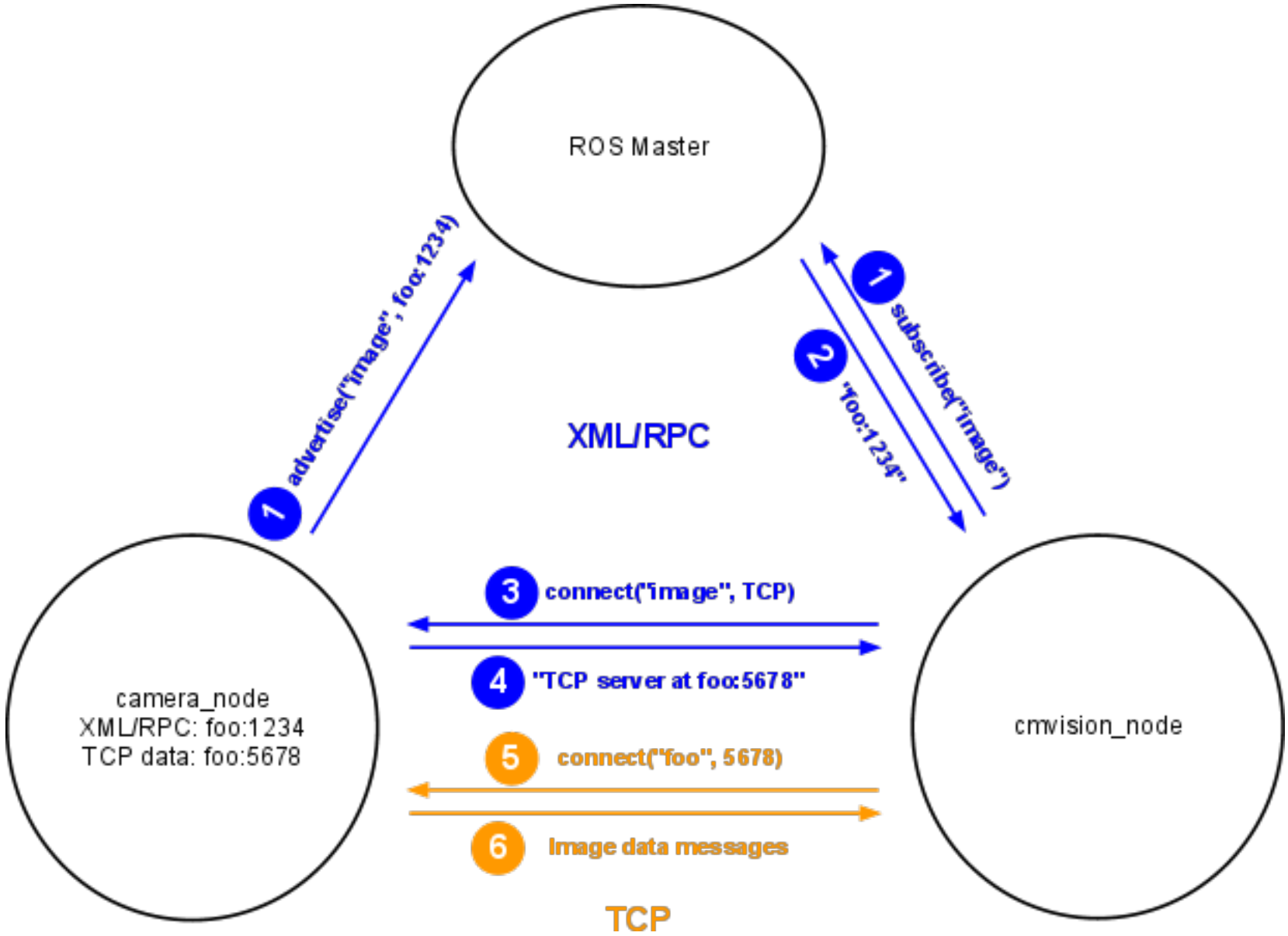
How it works

- 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

- Let's look at how communication between 2 nodes is setup at the packet level.

[adapted from slide by Chad Jenkins]

Matchmaking at a lower level



[adapted from slide by Chad Jenkins]

More about matchmaking

- Subscription to a topic is typically non-blocking
  - This means that a node can do other work while it is waiting for a subscription to be fulfilled
- A node can also unsubscribe whenever it wants to

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

Review

- ROS is a peer-to-peer *robot middleware* package
- We use ROS because it allows for easier *hardware abstraction* and *code reuse*
- In ROS, all major functionality is broken up into a number of chunks that communicate with each other using messages
- Each chunk is called a *node* and is typically run as a separate process
- Matchmaking or bookkeeping between nodes is done by the ROS Master

Learning ROS

- Here are some links that provide an overview of ROS
  - http://courses.csail.mit.edu/6.142/wiki/images/0/05/Icraoss09-ROS.pdf
  - http://www.ros.org/wiki/ROS/Introduction
  - http://courses.csail.mit.edu/6.142/wiki/images/a/aa/Introduction_to_ROS.pdf
- ROS Cheatsheet
  - http://www.ros.org/wiki/Documentation?action=AttachFile&do=get&target=ROScheatsheet.pdf
- These links assume a decent understanding of robotics and sufficient programming experience.
- Our goal this semester is to go through all these concepts using a number of examples and assignments.

Reading Assignment 1

- Reading Assignment 1 is due tomorrow night at 10PM by email.
  - The reading response should be in *plain-text*
  - I will go through your responses tomorrow night and discuss some of the common questions in class on Wednesday
  - As I get time, I'll send out a more complete list on the class mailing list.