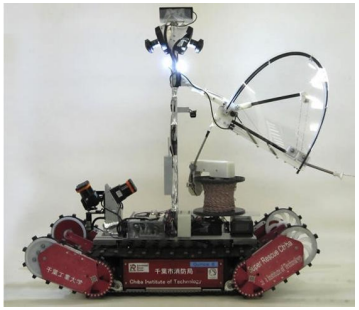
Gazebo in the DARPA Virtual Robotics Challenge

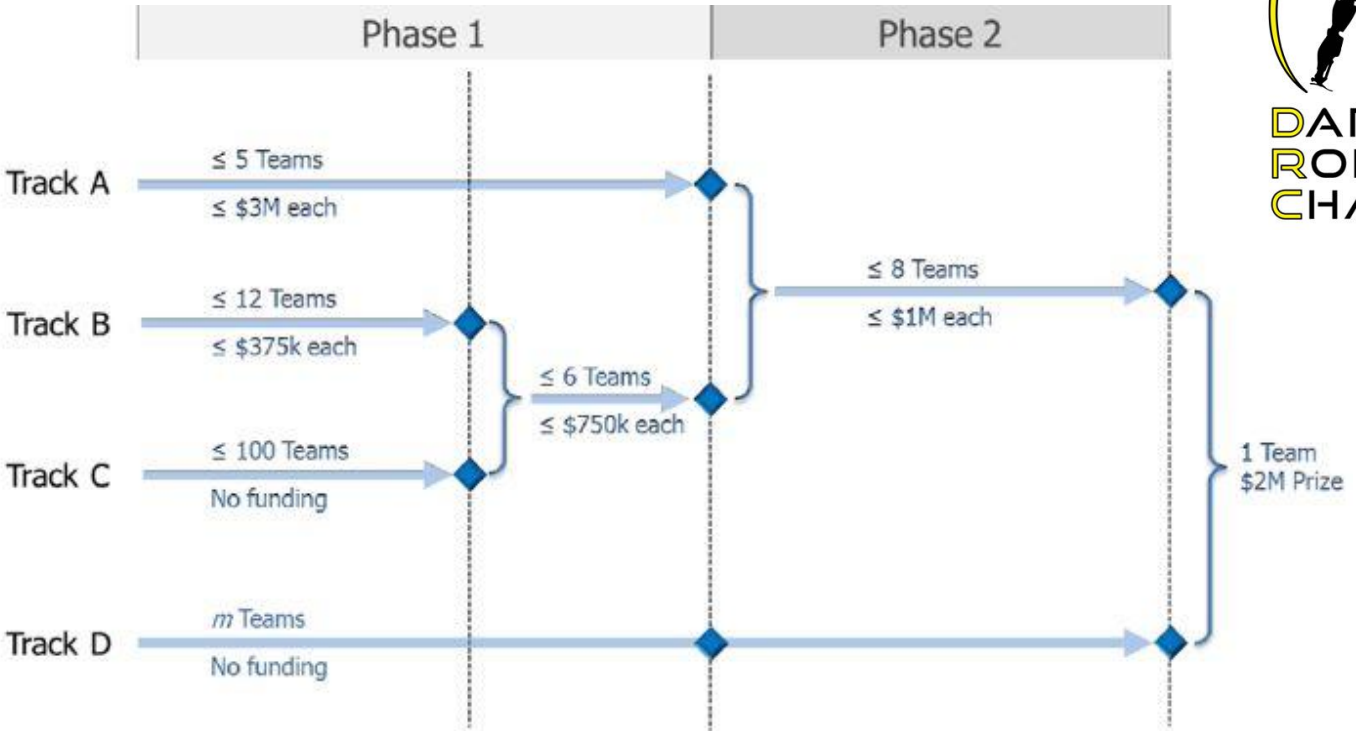
Simulating robots and environments for real-time competitions

The Future of Robocup Rescue Simulation Workshop
March 1, 2016

DRC: Darpa Robotics Challenge



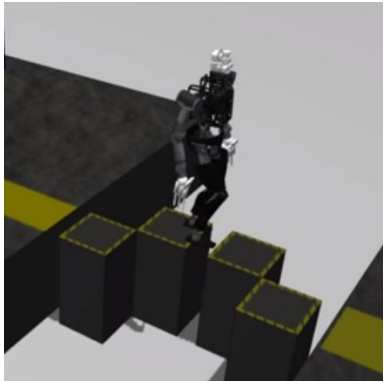
DRC Timeline

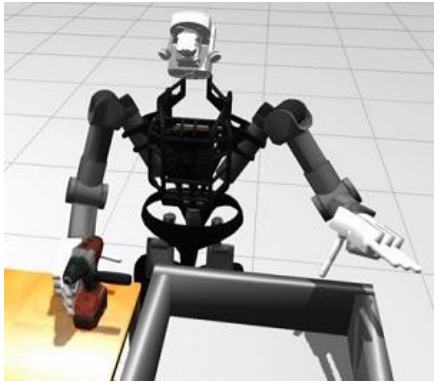


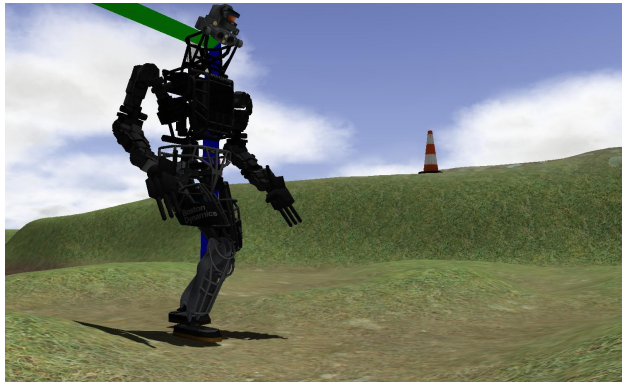
DARPA ROBOTICS CHALLENGE

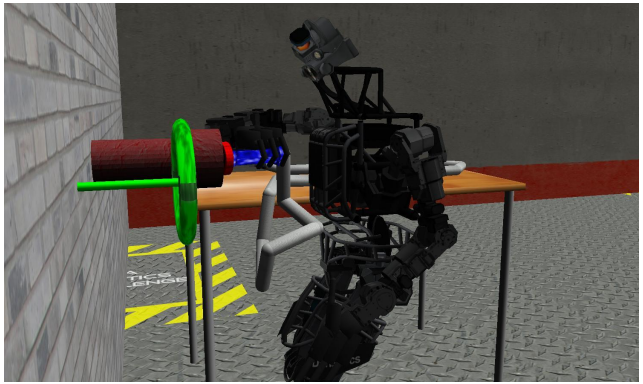
2013
VIRTUAL
DARPA ROBOTICS CHALLENGE

VRC: Virtual Robotics Challenge









VRC Overview

Cloud-based competition.

Simulate degraded communication.

Focus on partial autonomy.

Teams from 8 countries.

- Brazil, China, Germany, Israel, Japan, Korea, UK, US

ATLAS
2x Speed

Simulation and VRC

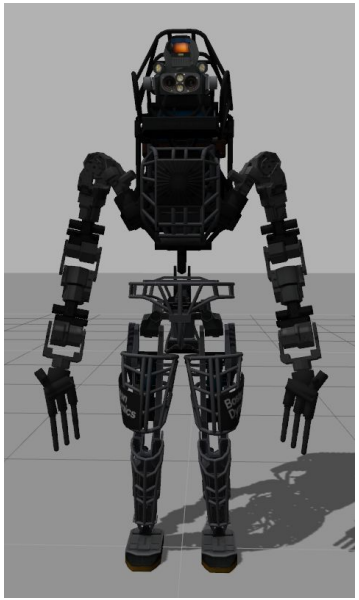
Why Simulation Based VRC?

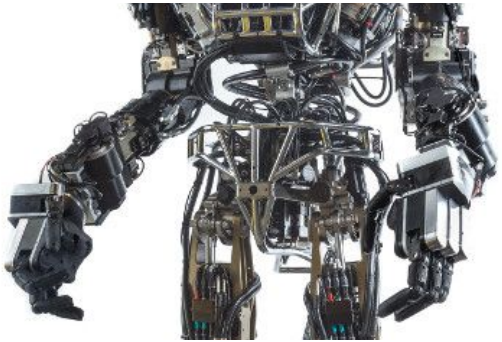
- Enables broader participation
- Robotics development tool
- Non-competitive technology
  - Don’t reinvent the wheel - make it open-source, available to all
- Simulator, a lasting legacy of the VRC

VRC Simulation Challenges

Atlas Model

- Models: Atlas (28) + MultiSense SL (1) + Sandia Hands (24) = 53 DOFs





Polaris XP900 (10 DOF)

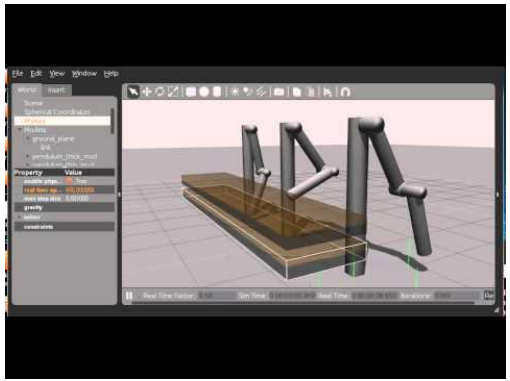
Modeling Special Environments

“Mud” plugin

- Simulate viscous drag
- Vehicle seat for stabilizing robot-vehicle interactions

Dynamic Constraints

- Screws for threading simulation
- Harness constraints for robot controller initialization



Physics Engine Requirements

Accuracy, fidelity vs performance

- Complete DRC tasks in simulation
- Simulation that "just works".

  Unconditionally stable, divergence-free:

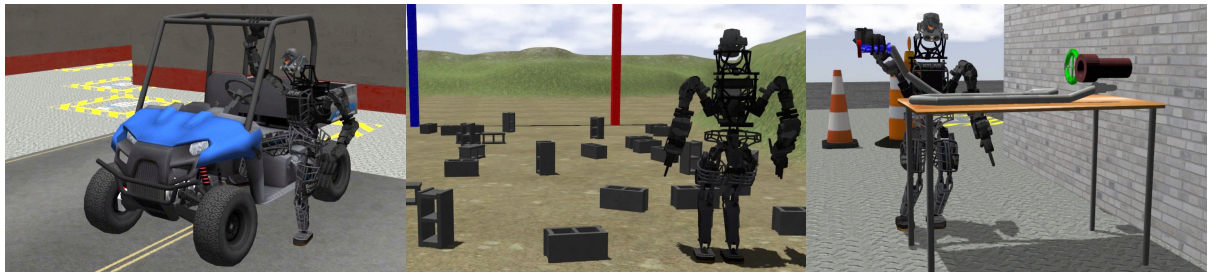
  with 10 ~ 40 contacts

  arbitrary joint torque applications

  arbitrary collisions, contacts, poses
- Near real-time performance

Performance Metrics

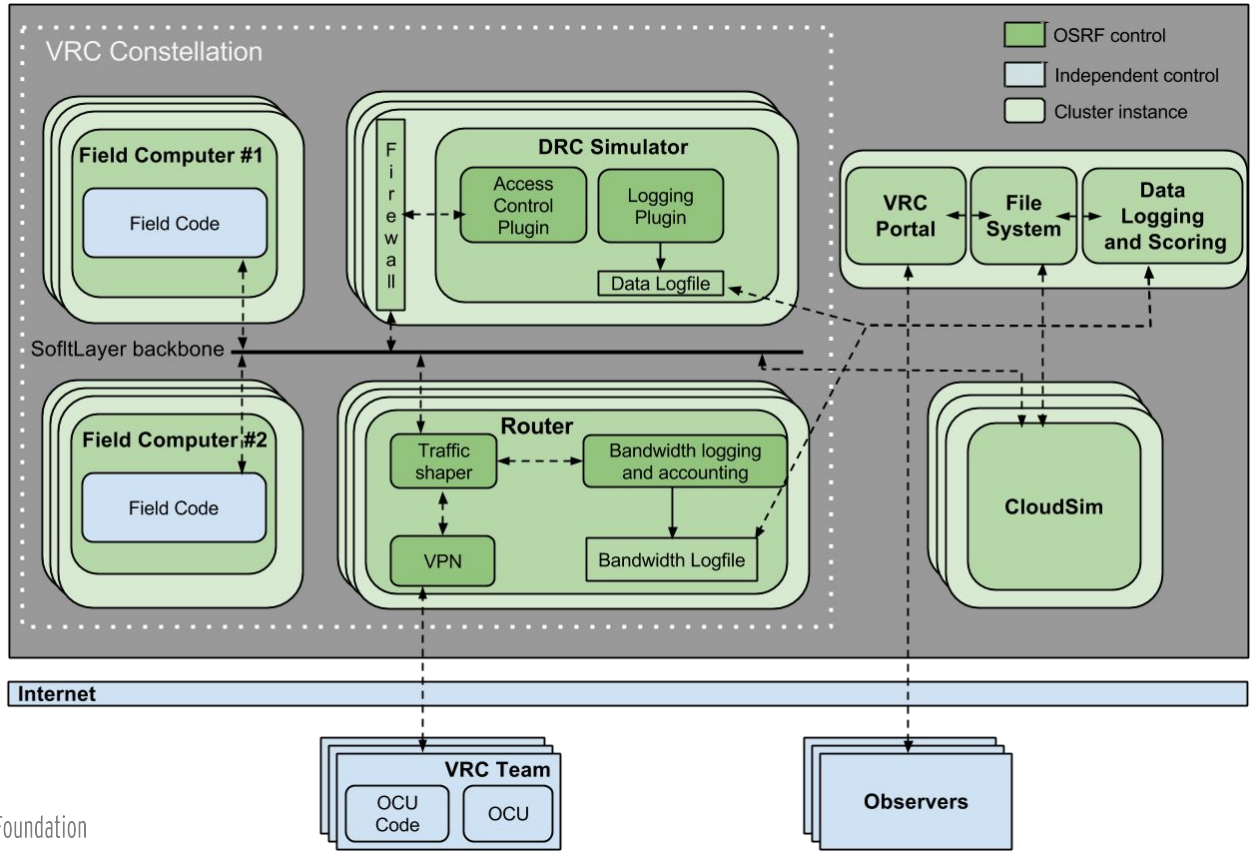
- Got close to real-time performance, enough accuracy for task completion.
  - Walking@VRC (~8 contacts.)
    - ~1.15X RTF on typical “gaming” desktop (Intel i7 @ 3.5GHz nVidia GTX 750)
    - ~0.75X on Softlayer cloud GPU machines (Intel Xeon @3.0GHz nVidia k20)
  - Grasping@VRC with Sandia hand (~20~40 contacts.)
    - ~0.85X desktop vs. ~0.65X cloud



Gazebo: Multiple Multibody Dynamics Solvers

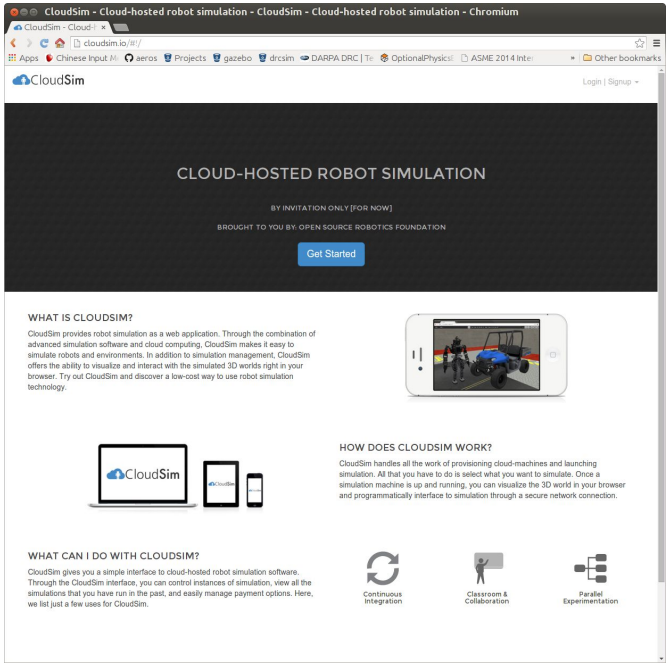
Open Dynamics Engine	Robotics, gaming bitbucket.org/odedevs/ode	
Bullet	Gaming, animation, Sony, AMD github.com/bulletphysics/bullet3	
Simbody	Biomechanics, Stanford github.com/simbody/simbody	
DART	Robotics, animation, Georgia Tech github.com/dartsim/dart	

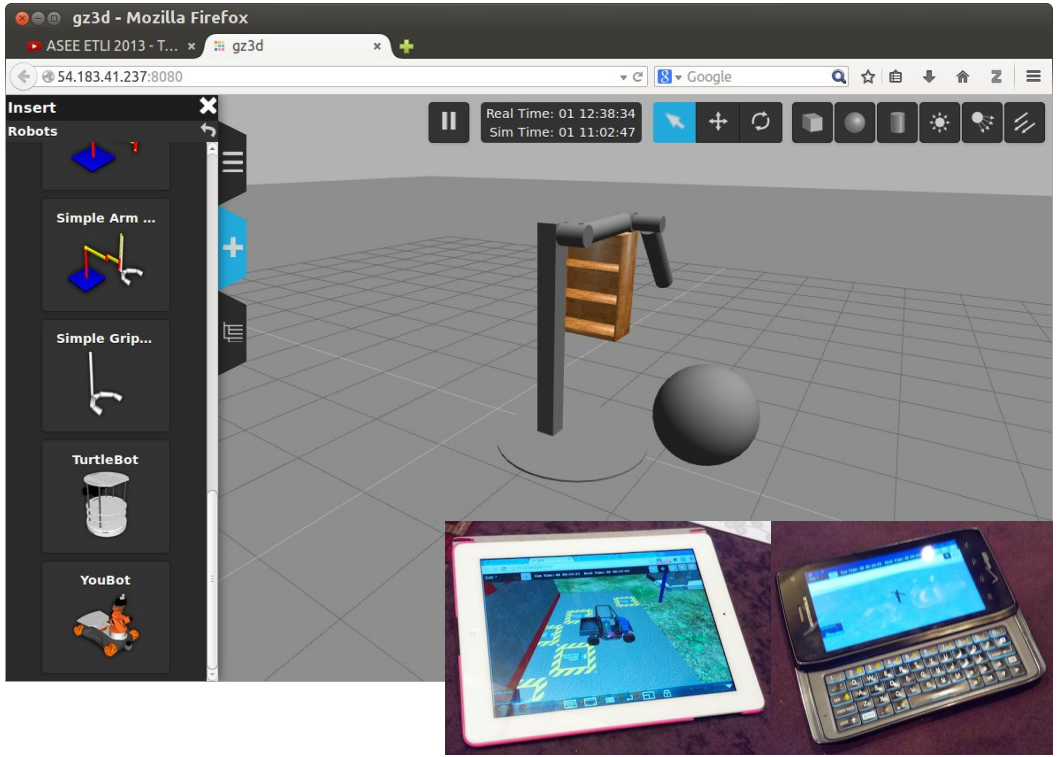
Cloud Based Simulation Competition



CloudSim and GzWeb

Gazebo Simulator in the Cloud





Not all cloud providers are equal

Amazon EC2 machines

- Simple to setup
- Pay by the hour
- Initial tests showed adequate performance

Last minute change

- All Amazon machines virtualized → Unpredictable latency
- Jump ship to Softlayer

VRC Security

Between teams

- No snooping on teams
- VPN: Secure communication between teams and clouds

Within team

- A team should not directly access simulation
  - Firewall
  - Added white lists to Gazebo
- Randomized schedule: Teams complete tasks in random order

Silver lining

Adjustable control loop

- Pause simulation to absorb network latency
- Parameterized window from 0 → n seconds

Cross-provider cloud infrastructure

- Cloud simulation for Amazon, Softlayer, OpenStack

The entire system works!

VRC Practice (Dress Rehearsal)

Test cloud server management

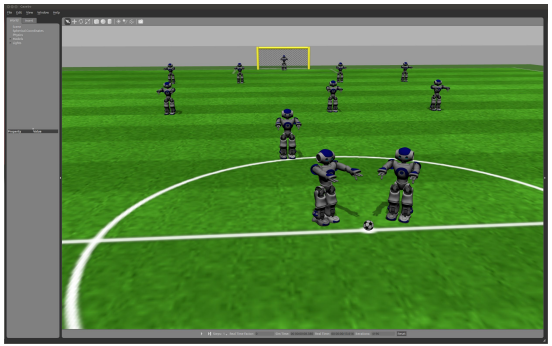
Test scoring, logging

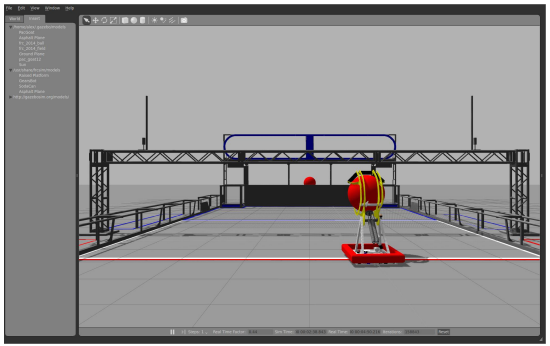
Test communication channels for participants, referees, tech support

Teams are on different time zones

Education

- FIRST: Use simulation for design, development, and testing
- Robocup:
    - soccer: Simulated Nao and simplified dynamics
    - rescue: Large indoor and outdoor search and rescue environments
    - @home: Autonomous robots operating in home environments
    - logistics: Flexible material and information handling in industry





Future

Windows & OSX support

Open-source walking controller

GUI Tools: Model editor, plotting, video creator

Improve multiple physics engine support

THANK YOU!