

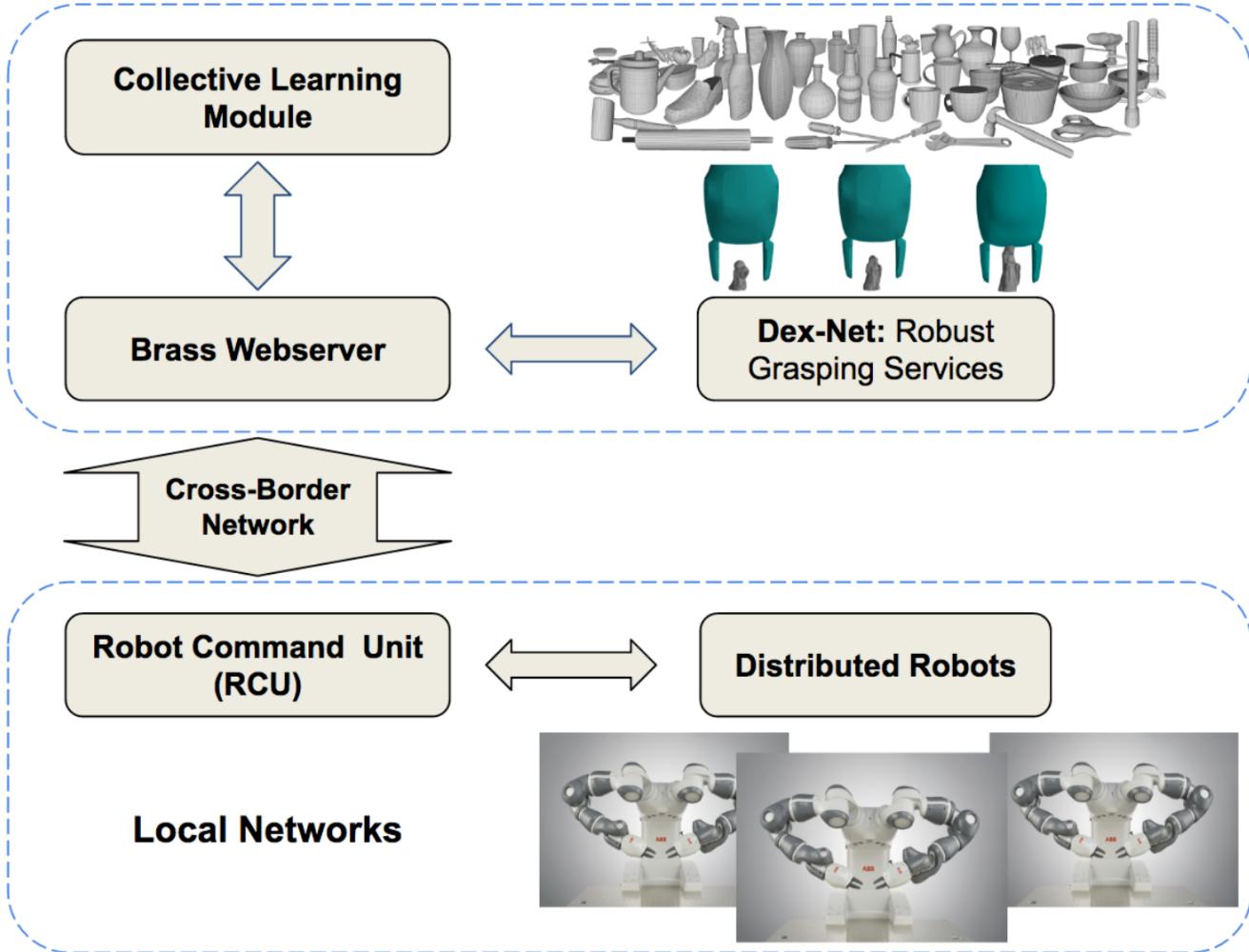
A Cloud Robot System Using the Dexterity Network and Berkeley Robotics and Automation as a Service (Brass)

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Christopher Correa, Steven Zheng, Qiang Li, Robert Zhang, Ken Goldberg

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Berkeley Robotic and Automation as a Service (Brass)

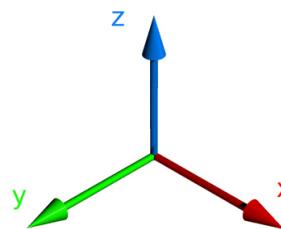
B. Kehoe, S. Patil, P. Abbeel,
and K. Goldberg, “A survey
of research on cloud robotics
and automation,” *IEEE
Transactions on Automation
Science and Engineering*,
2015



Advantages of Brass

- Simple cloud robotic interface
- Enabling data sharing and collective learning
- Reliable and secure network for robotics

None Standard “Wizard” Chess Playing with YuMi



“Dexterity Network”: Dex-Net

- 10,000 3D object models
- 100-1000 candidate grasps per model



Jeff Mahler, Florian T. Pokorny, Brian Hou, Melrose Roderick, Michael Laskey, Mathieu Aubry, Kai Kohlhoff, Torsten Kroeger, James Kuffner, Ken Goldberg. “Dex-Net 1.0: A Cloud-Based Network of 3D Objects for Robust Grasp Planning Using a Multi-Armed Bandit Model with Correlated Rewards.” IEEE International Conference on Automation Science and Engineering (ICRA) 2016

None Standard “Wizard” Chess Playing with YuMi

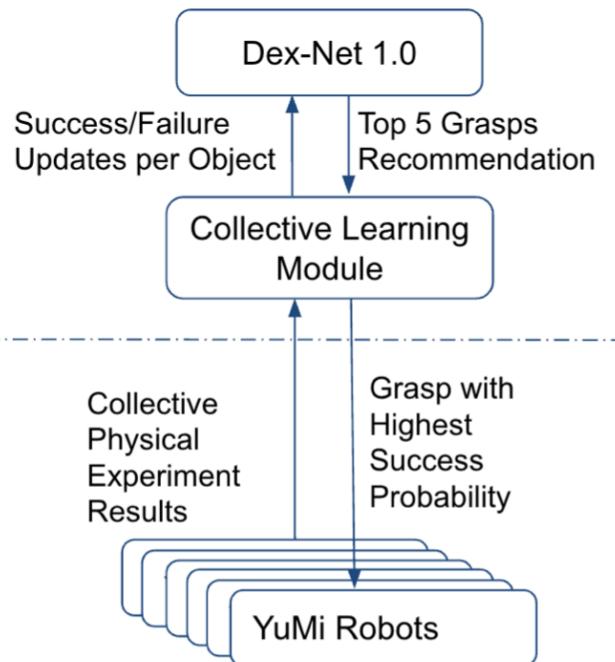


Grasp Success Rate over 50 Attempts

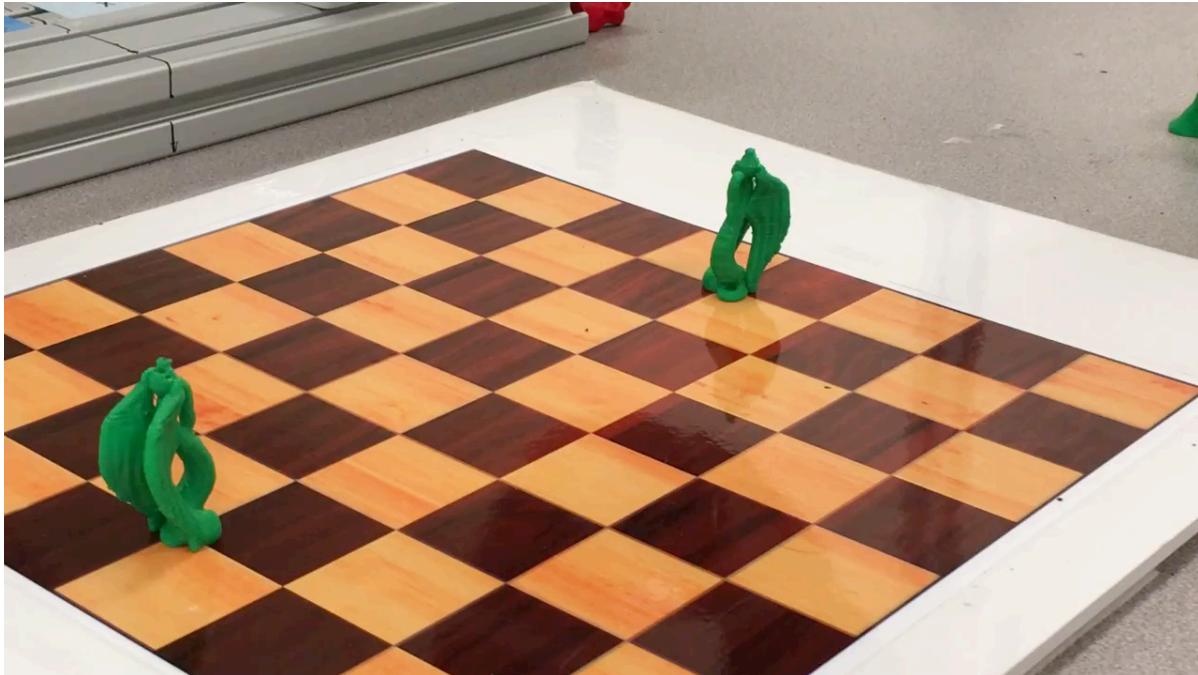
	Hardcoded x-axis	Hardcoded y-axis	Dex-Net
King	94	100	100
Queen	84	100	98
Rook	96	98	100
Bishop	98	72	98
Knight	100	100	100
Pawn	94	76	100

Collected Learning Module for Faster Empirical Experiments

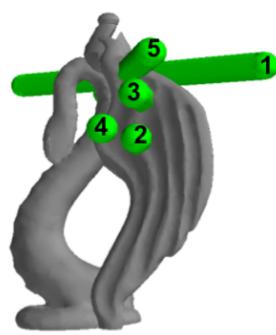
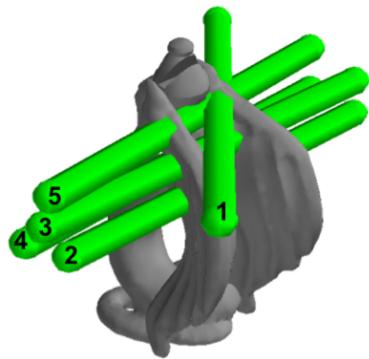
BRASS Server in the Cloud



Distributed Robots



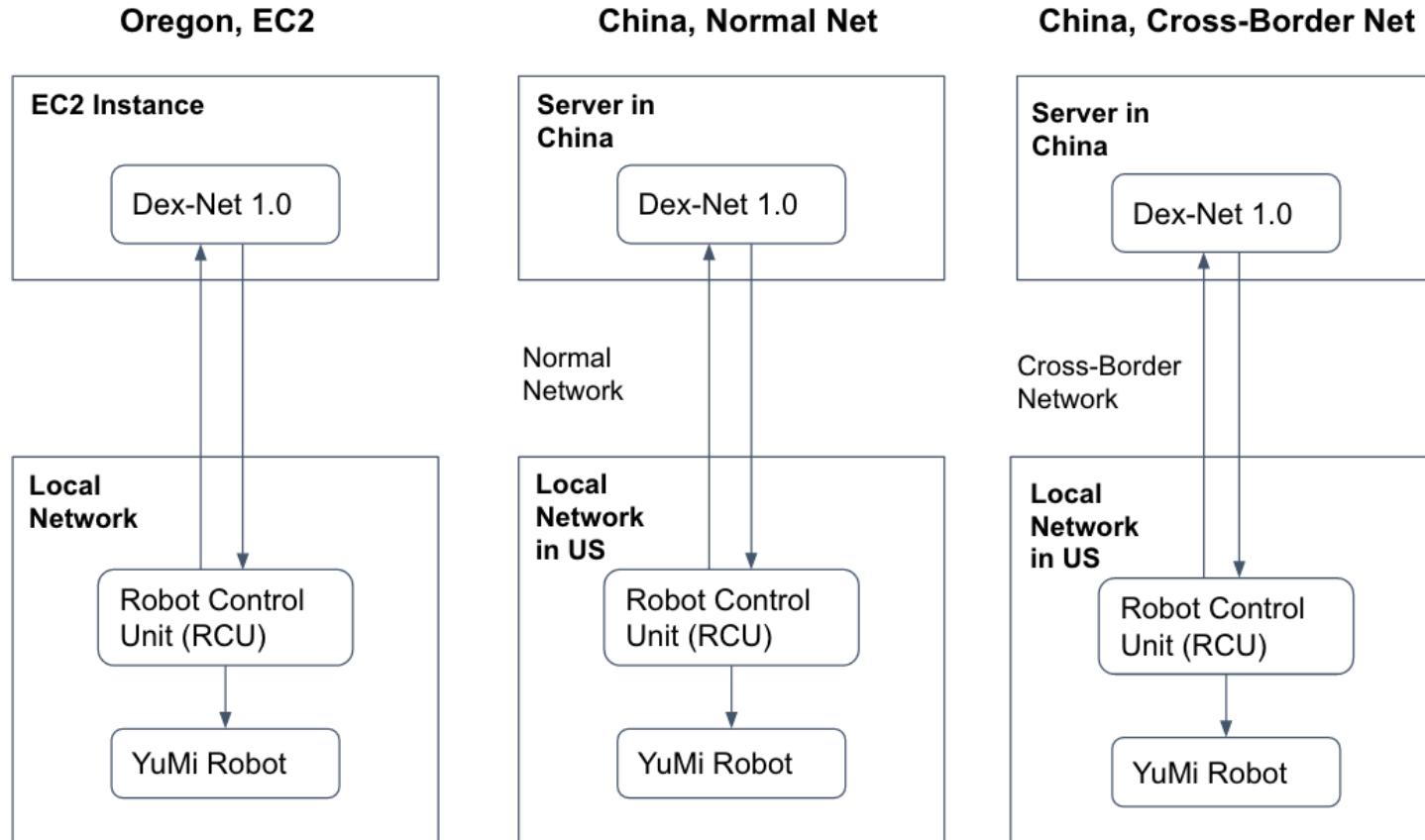
Success Rate of Grasps from Collected Learning Experiments



SUCCESS PROBABILITIES (PERCENTAGE) OF THE TOP 5 DEX-NET GRASPS BASED ON 30 PHYSICAL TRIALS

Grasp	1	2	3	4	5	Best
King	100	100	100	100	100	100
Queen	100	97	87	67	100	100
Rook	100	87	100	100	100	100
Bishop	57	87	100	60	100	100
Knight	87	63	100	100	27	100
Pawn	47	50	100	100	100	100

Value of Cloud Robotic Services Outweigh Communication Costs



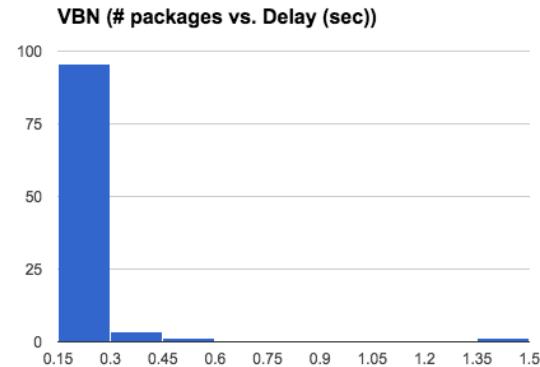
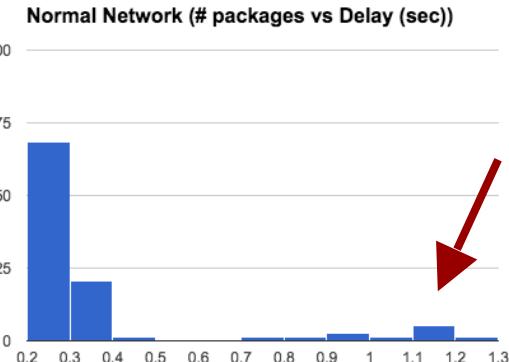
Value of Cloud Robotic Services Outweigh Communication Costs

ROUND-TRIP TIME TO RECEIVE GRASPS FROM DEX-NET

	Freq (Hz)	Mean (ms)	Variance (ms)
Local	1000	0.11	0.0011
Oregon, EC2	30	31.50	0.0018
China, normal net	3	303.10	54.2180
China, cross-border net	5	197.03	0.3239

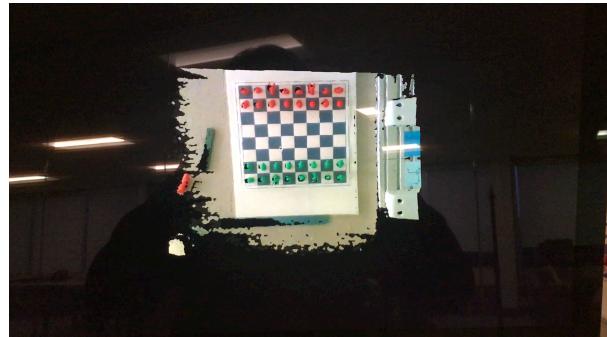
Latency Critical Tasks:

1.5x Faster in latency
more reliable with low variability

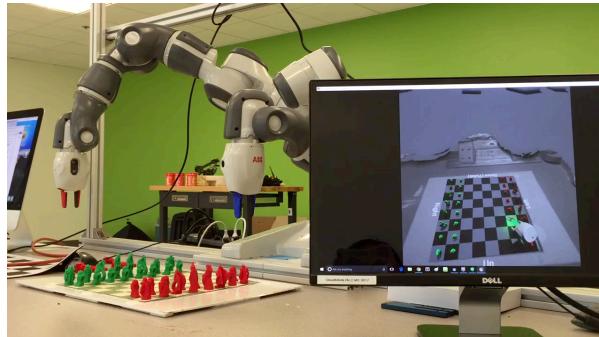


“Wizard” Chess Extension using Brass

Vision Feedback



VR Control



Mobile Phone Control



Future Work

- Use Brass to program more dynamic robotic tasks
- Collectively learn robotic tasks from human demonstrations

Acknowledgement

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