

DAvinCi: A Cloud Computing Framework for Service Robots



Vikas Reddy, Rajesh Arumugam, Dr. Liu Bingbing, Dr. Wu Xiaojun, Goh Wai Kit, Kang Dee Meng, Krishnamoorthy Baskaran, A.Senthil Kumar, Foong Foo Kong



Consumer Electronics/Network Storage Technology Division
Data Storage Institute

Motivation

- The service robotics industry is forecasted to become a US\$15b industry by 2015 with wide spread usage in homes, institutions, commercial establishments and law enforcement [1].
- **We envision a team of heterogeneous robots working in such large environments** to execute tasks such as janitorial maintenance, item delivery and surveillance.
- Existing robotics architectures are well designed for individual robots and enable the robot to perceive its environment only through on-board sensors. There is no system available today to facilitate information sharing between multiple robotic agents and their sensors [2].
- We created the DAvinCi system to augment the existing frameworks to enable **multi agent interaction, coordination and collective intelligence**.

Technological Challenges

The following are the primary challenges that are addressed in the system:

- ❑ **Co-operative behavior among the robotic agents**
- ❑ Efficient sharing of computational and storage resources which should take into consideration **common data formats, communication delays, speed of computation of the various robotic algorithms**.

The DAvinCi Architecture

- ❖ DAvinCi is a software/ hardware architecture that leverages on unique capabilities of individual taciturn agents and empowers them to perform intelligent and complex operations **through efficient information sharing and co-operative behavior algorithms**.
- ❖ The DAvinCi Framework incorporates a **scalable and highly parallel architecture** providing a cloud based platform service for Service Robots.

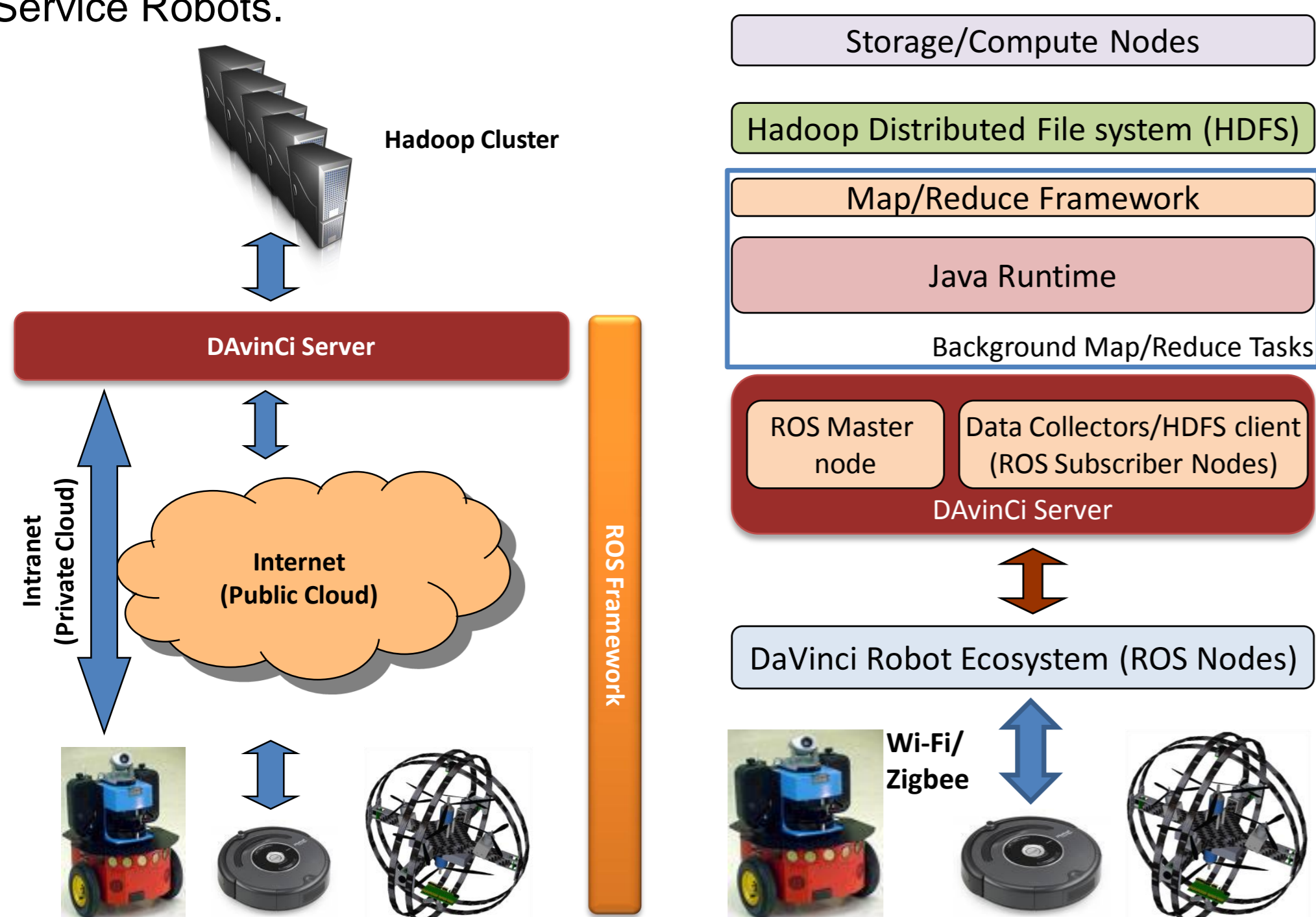


Figure 1. (left) High Level System Design (right) DAvinCi Cloud Computing Architecture

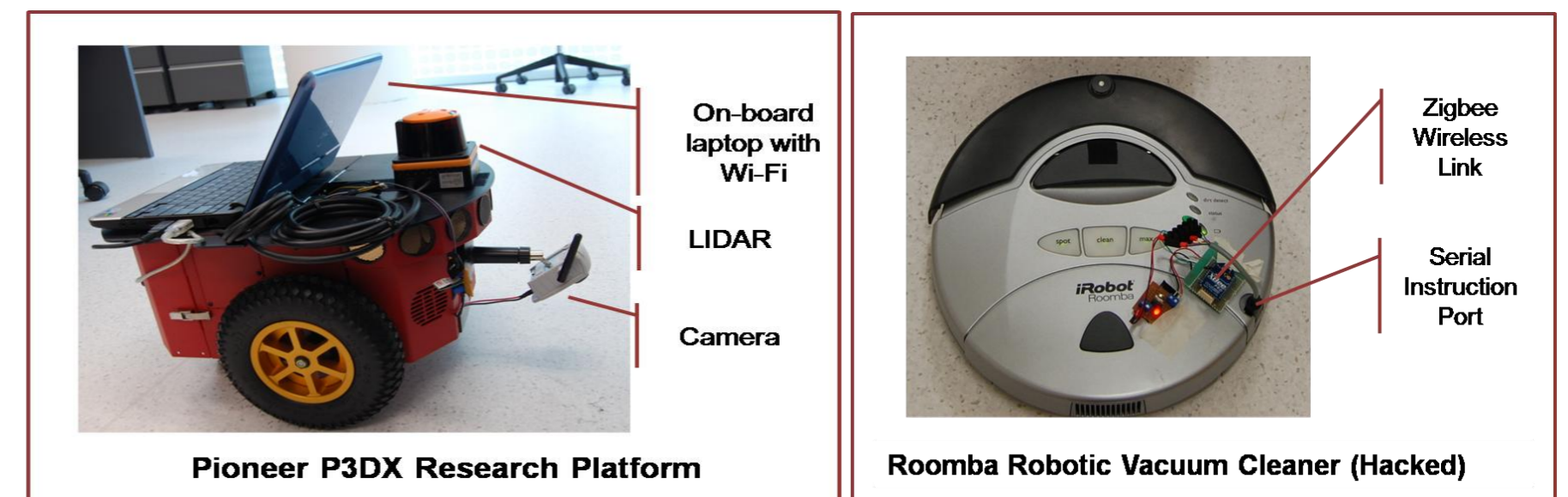


Figure 2. (left) The well equipped (right) The minimal Roomba

Process: The environment is first scanned by the P3DX using the LIDAR and a 2D map is constructed by the Server using the FastSLAM algorithm (figure 3, left). Using this map, the P3DX does a routine surveillance run of the environment looking for red markers and tags their position. The Server then commands the Roomba to the red markers and on reaching the markers, the Roomba initiates the vacuuming process..

Results: The DAvinCi system performed exceptionally well under the lab constraints and the demonstration's key images are shown in sequence in Figure (3) to corroborate our claims.

Discussion: The system currently works well for small scale environments with minimal noise. Problems with network latency were experienced and overcome with local level intelligence. While our architecture is scalable by nature, the network latency and bandwidth effects have not been modeled and can only ascertained with a real working setup.

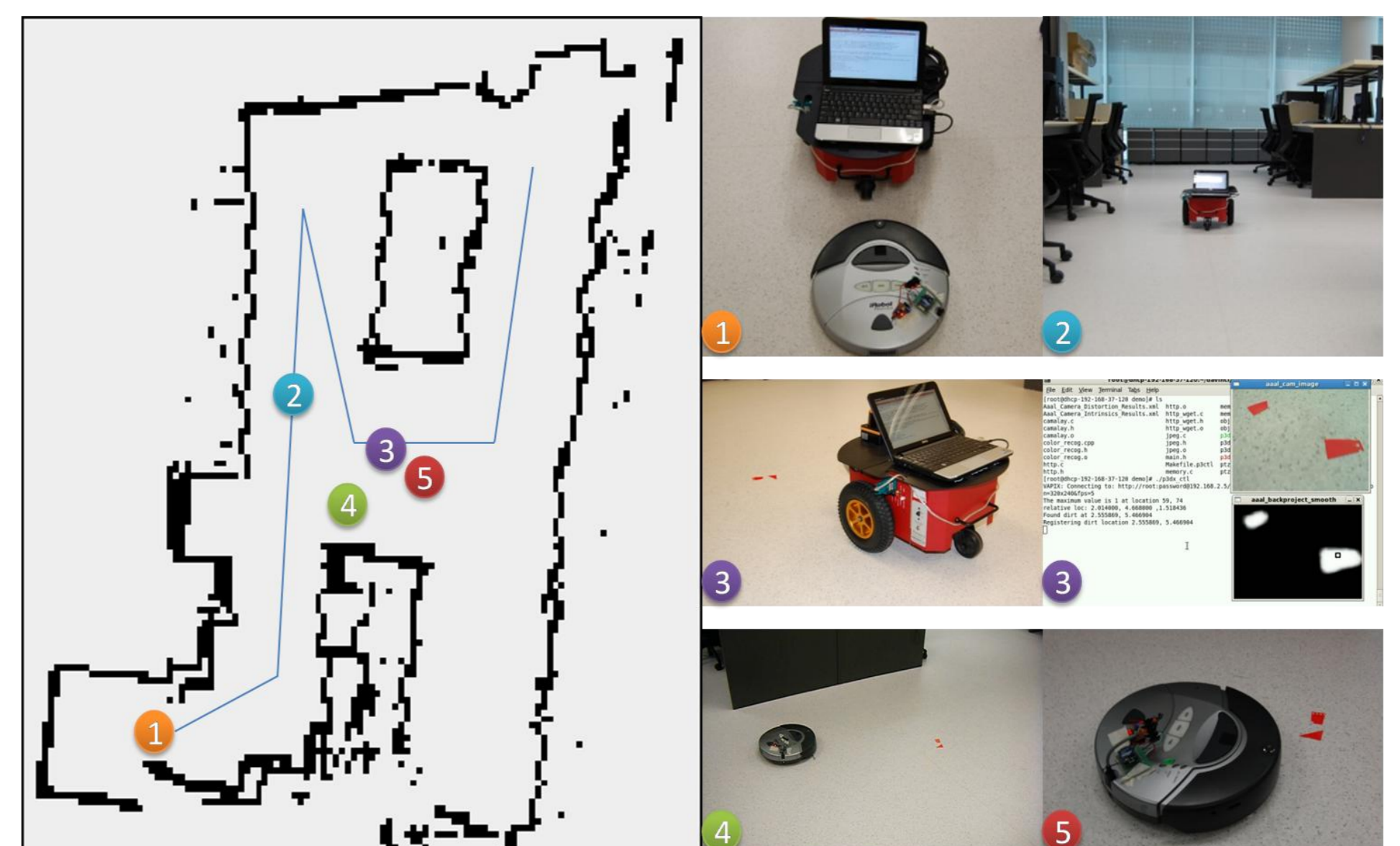


Figure 3. (left) 2D Map of the environment (right) The mission sequence.

Future Work and Conclusion

The DAvinCi system is a step forward in resource and intelligence management for robots and other distributed agents. The issues related to environment noise, network latency and bandwidth will be understood further in our forthcoming deployment of robots on Level 14 of Fusionopolis. Robots will coexist with humans and will perform routine maintenance and surveillance tasks under DAvinCi's supervision.

The DAvinCi system is the only one of its kind providing intelligence and localization information via a **Software as a Service (SaaS)** model. We are confident about its application scope in the field of robotics, cell phones and other large system with distributed agents.

References

1. ABI Research. Personal robots hit the consumer mainstream[Online] 2008.
2. A. Saffiotti and P. Lima. Two "hot issues" in cooperative robotics: Network robot systems and formal models and methods of cooperation, 2008.

Proof of Concept Experiment

Objective: To demonstrate visual information and processor resource sharing capability of the DAvinCi server using two robots. The mission assigned to the DAvinCi server is to survey the environment, track the position of red markers (dirt) and deploy the vacuum cleaner to these (dirty) areas for cleanup.

Setup: Our system consisted of the DAvinCi server running Player/Stage on a single node x86 machine and two robots – a P3DX research platform with on-board camera and LIDAR and the Roomba vacuum cleaner in instruction mode inside a computer lab as shown in figures (2) and (3).