Robotics Middleware for Healthcare

RoMi-H

18 August 2020

Centre for Healthcare Assistive & Robotics Technology

HOPE technik

IHiS Because IT's in Healthcare

open robotics

Agenda

Item	Presenter
Why do we need RoMi-H ?	Selina Seah, ACEO CGH & Director, CHART
What is RoMi-H and what can it do?	Morgan Quigley, Open Robotics
How can we use RoMi-H?	Lim Joo Siang, HOPE Technik
Live demo	Wan Sabrina, CHART supported by Open Robotics & HOPE Technik
Break	
Functionalities, tools & utilities in the RoMi-H 1. Traffic editor, RoMi-H core, visualisation & simulation 2. Other tools: Bolt on Kit, RAMP	Michael Grey, Open Robotics Lim Joo Siang, HOPE Technik
Closing remarks	Lim Chui Ping, Deputy Director, CHART

Why do we need RoMi-H?

Challenges in Healthcare

Shifting demographic & healthcare workforce shortage continue to burden the healthcare system and drive cost upwards

Average life expectancy
82.9

By 2030
1 in 7 adults will have diabetes
1 in 220 adults will have a heart attack
1 in 100 slides will have a cancer

By 2030
1 in 4 people will be > 65

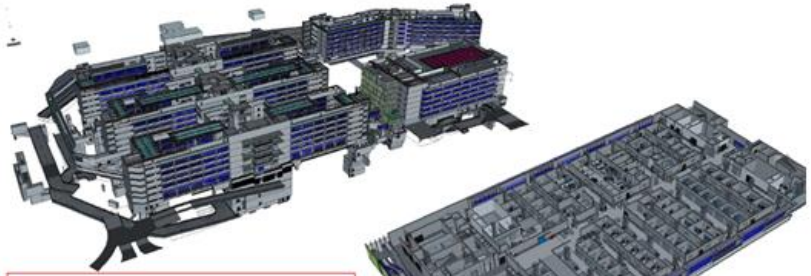
7.8 nurses per 1,000
Shortfall of 30,000 by 2020

By 2030
Old age support ratio will drop to 2.7 from 4.8 in 2018

By 2030
Healthcare expenditure to be 3.5% of GDP
(from current 1.6%)

Vision – Building Smart Healthcare and Hospitals of the Future

Woodlands Health Campus



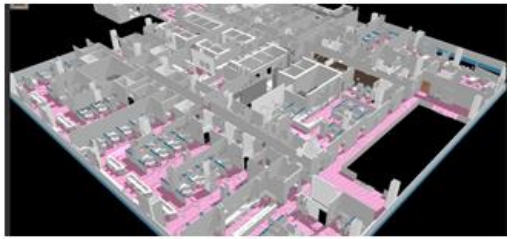
Woodlands Health Campus - IFC Import

WHC - floor extraction

National Cancer Centre Singapore

National Cancer Centre Singapore

NCCS - Simulated Floor extraction



Enabling Smart Logistics, Smart Care, Smart Patient and Hospital to Home programmes (Smart Community)

Sample of Robotics in Singapore Healthcare

Specimen delivery in lab

Food delivery

Surgical robots

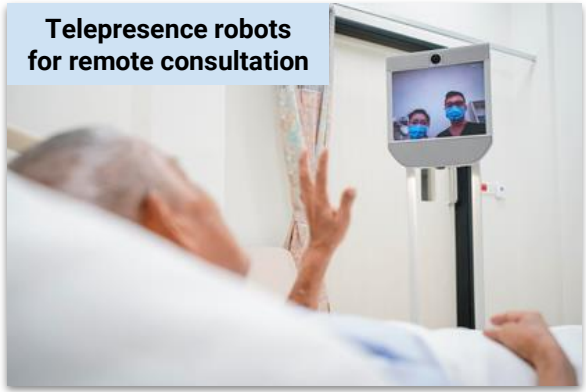
Ward delivery

COVID-19 operations

UV disinfection robots

Food deliveries in isolation facilities

Telepresence robots for remote consultation



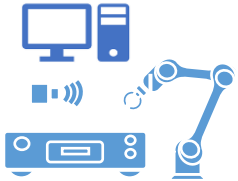
Challenges in Multi-fleet Deployment

Lack of Interoperability

- Lack of communication and integration between robots, medical devices, building infrastructure and health IT systems
- Lack of guidelines & standards for deployment of multi-fleet robotic solutions in dynamic Healthcare environment

Infrastructure Constraints

- Need to interface with lifts and doors
- Dedicated routes and lifts for robot
- Need to dedicate space for different types of chargers for different make/model of robots



Lack of Realistic Test Environment

- Challenging and expensive to test effectiveness of large scale deployment of robotic solutions

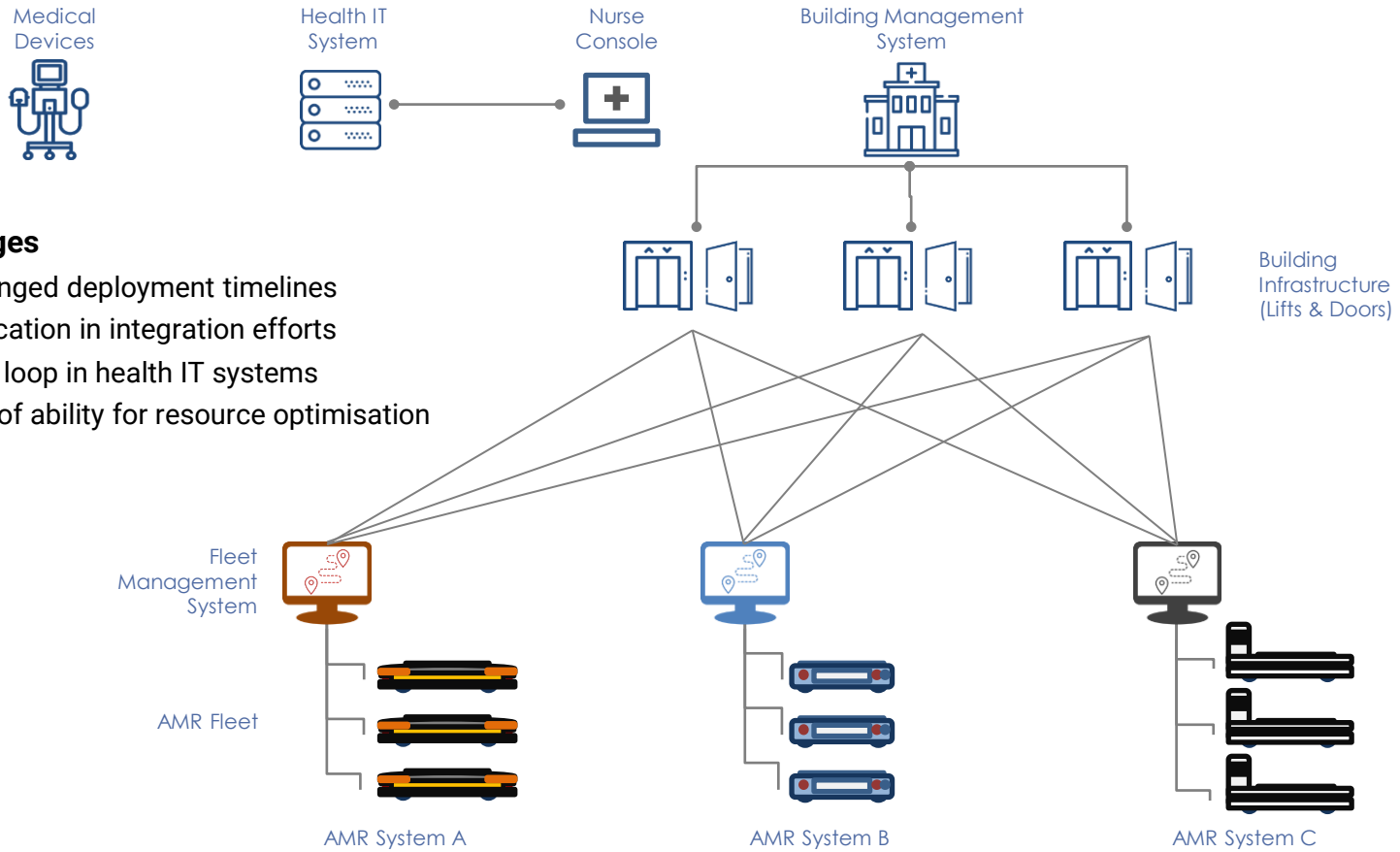
Dynamic Environments

- Dynamic human traffic and crowds
- Direct contact with high volume of untrained personnel and visitors
- Lack of guidelines and risk assessment for Human-Robot Interaction

Cybersecurity Concerns

- Increased reliance on network for data transmission

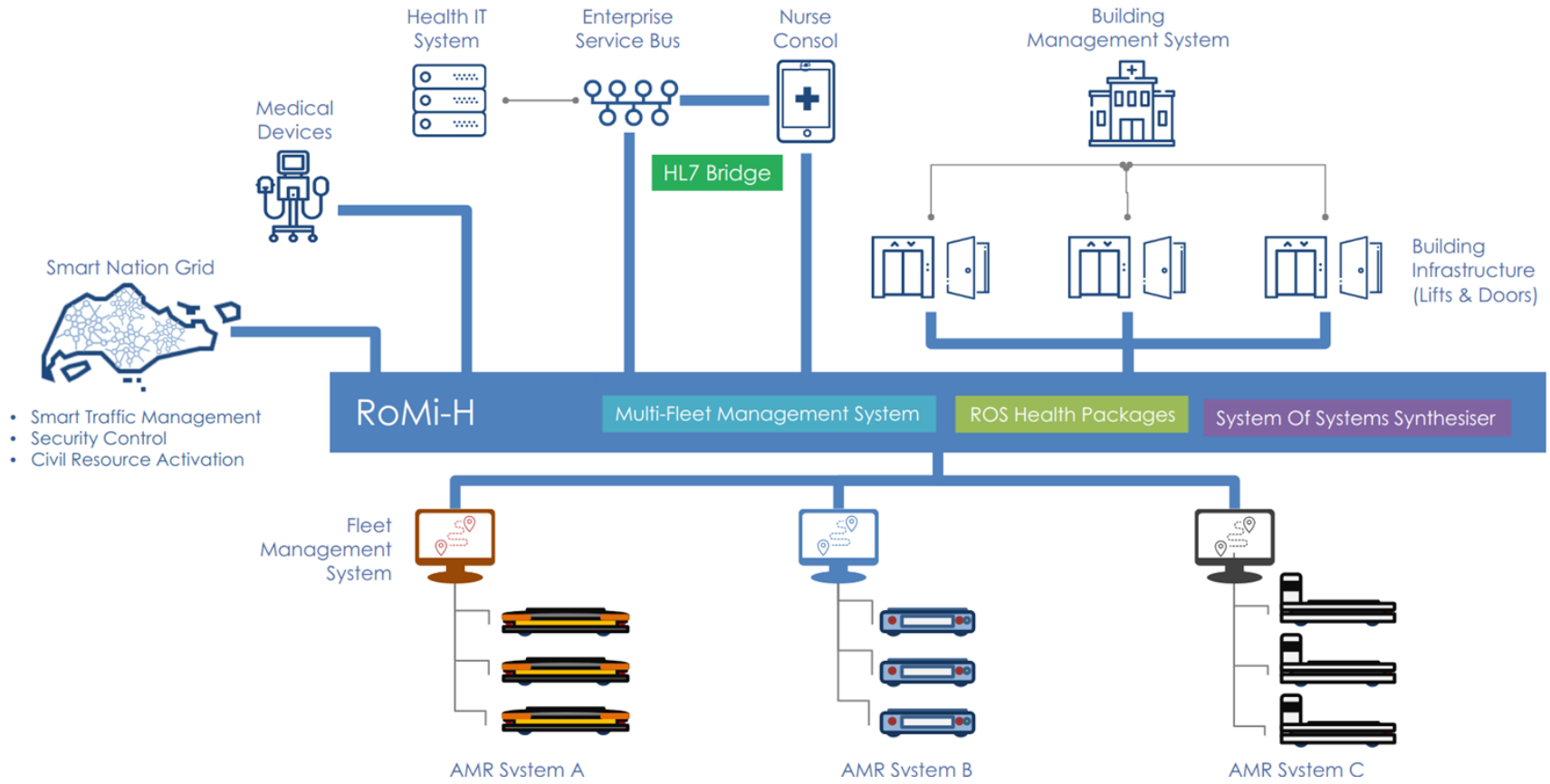
Current situation…



Challenges

- Prolonged deployment timelines
- Duplication in integration efforts
- Open loop in health IT systems
- Lack of ability for resource optimisation

The Solution: Scaling Automation with RoMi-H



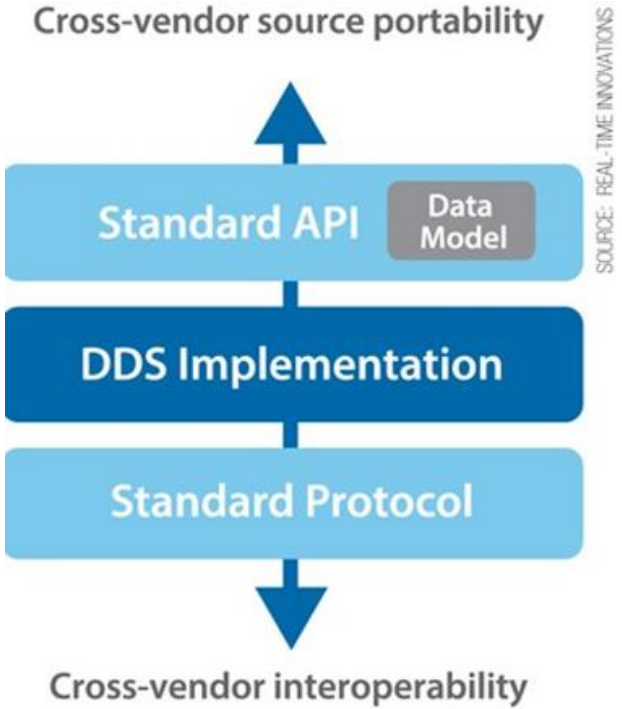
Organizing ourselves to solve these challenges

Consortium partner	Role	Website
Centre for Healthcare Assistive & Robotics Technology (CHART)	**Development of architecture & physical demo platform**	https://www.cgh.com.sg/chart/sharp/romi-h
IHiS – Because IT's in Healthcare	**Security, repository, development of infrastructure**	https://www.ihis.com.sg/
open robotics	**Design of common services and large-scale virtual test farm infrastructure**	https://www.openrobotics.org/
HOPE technik	**Integration domain & interfaces to healthcare IT systems**	https://www.hopetechnik.com/

DDS in RoMi-H

OMG's **Data Distribution Service** ("DDS") as the underlying communications standard.

- ➔ Mature and proven technology, deployed for commercial, government and university projects.
- ➔ An efficient publish/ subscribe standard for high performance and scalability
- ➔ Supports authentication and encryption, with turnkey messaging security solution
- ➔ Supports adaptors to other technologies, routing and transformation capabilities



How will RoMi-H benefit hospitals

Interoperation: Enterprise IT systems , building management systems, medical devices, IoT enabled systems and robotic systems will be able to interoperate and share data based on real use-cases

Optimisation: Ability to share common building infrastructure will improve utilisation of autonomous mobile robots

Visibility: Hospital operators can have better visibility on resources and will be able to plan better

Scalability: RoMi-H allows scalability across new types of robots as well as systems in the future

Cost savings: Reduce cost by lowering system integration efforts and lesser duplication

Smart Nation Connectivity: Improve national inter-agency coordination

Goal - RoMi-H as The **Standard** and **Baseline Infra for public hospitals & Nursing Homes**

The RoMi-H Developmental Stages

1

Smart Ward

- Robot task assignments
- Nurse-patient-robot communications
- Robot-lift / robot-medical device communications
- Robot-Health IT Systems communications

2

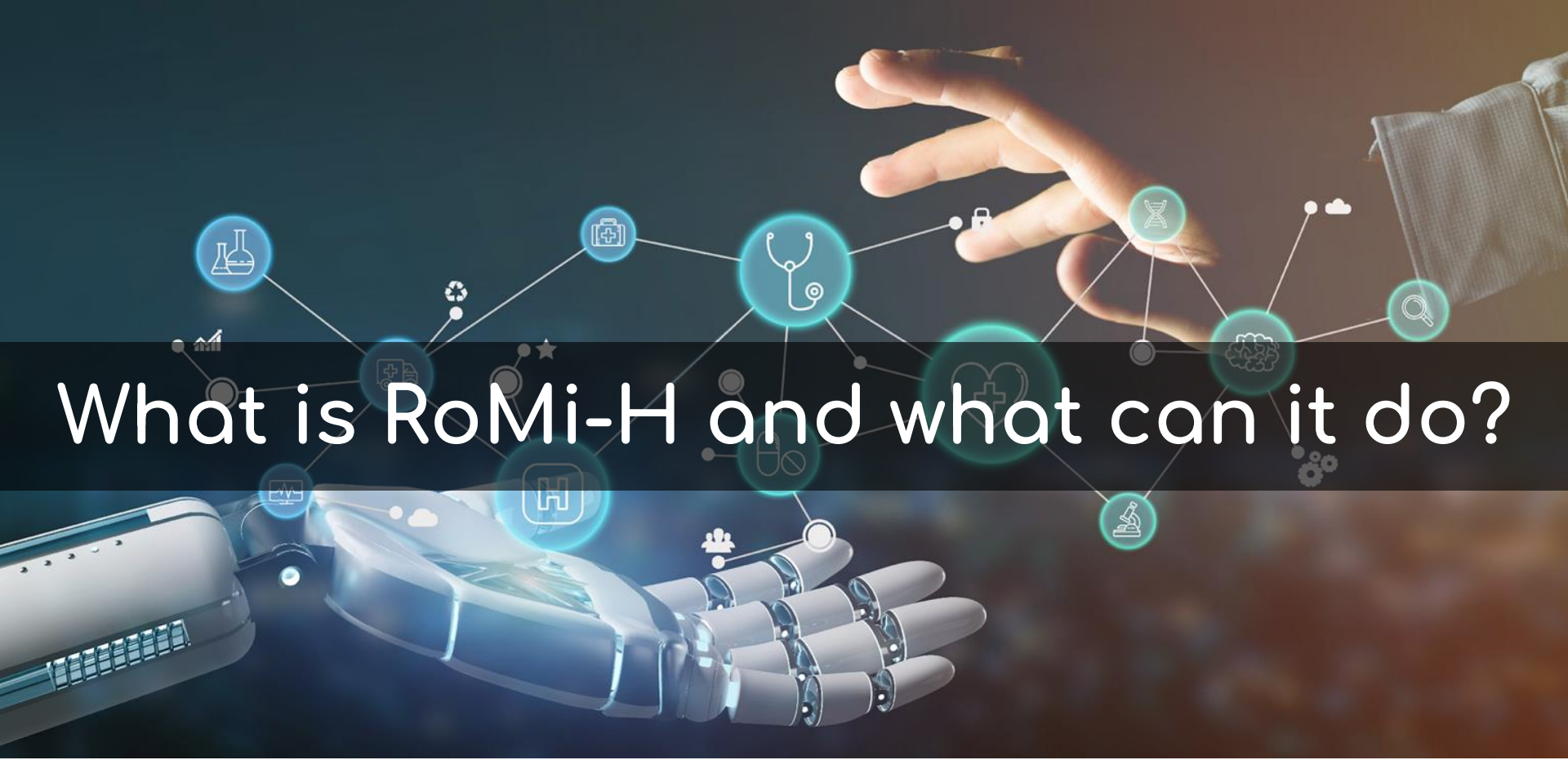
Smart Hospital

- Scheduled robot task assignments from HIT
- Multiple robot fleet management
- Hospital emergency protocols integration
- Patient care and asset optimisation systems

3

Smart Nation

- Connection to Smart Nation grid
- Connection to other government agencies
- National efforts in Emergency responses



What is RoMi-H and what can it do?

The next frontier : multi-fleet production systems

- Robotics is a rapidly-developing field
  - delivery is a common application today
  - new applications will emerge
  - new companies will emerge
  - facilities will need to quickly adapt

- Certain process flow automations inherently require two or more robots to interact with each other
  - the best robots for each sub-task may come from different vendors
  - **multi-vendor integration** must be possible!

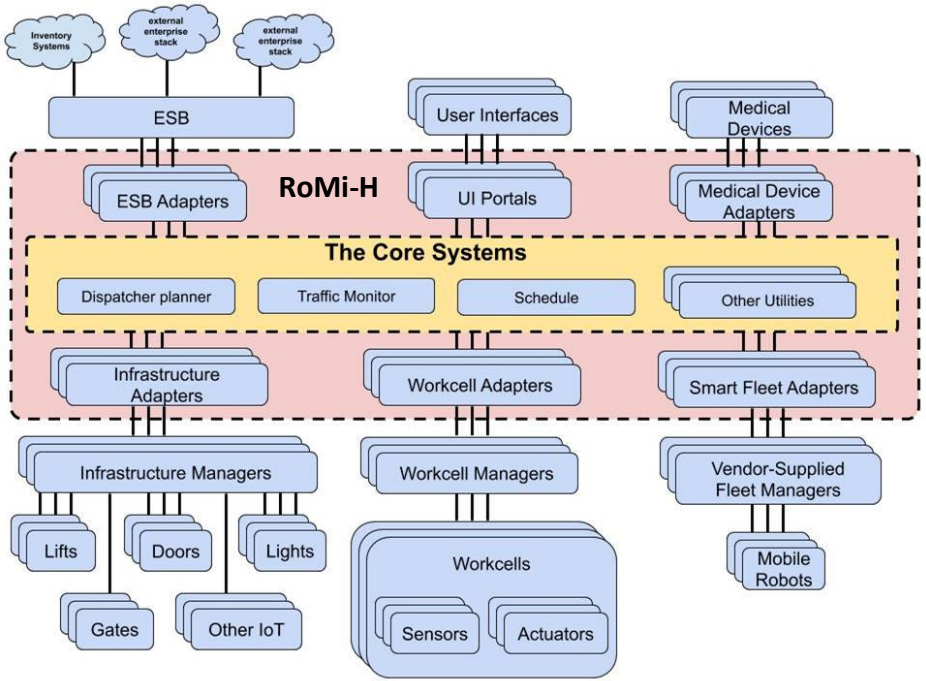
What is RoMi-H?

RoMi-H is a middleware; a collection of libraries and tools that facilitate interoperability among:

- Heterogeneous robot fleets of any OS
- Smart building & Infrastructure: Lifts, Doors, ...
- Health IT Systems
- Automation Systems (e.g. workcells, dispenser, pick & place)

Allows for visibility and centralized status of inter-connected systems

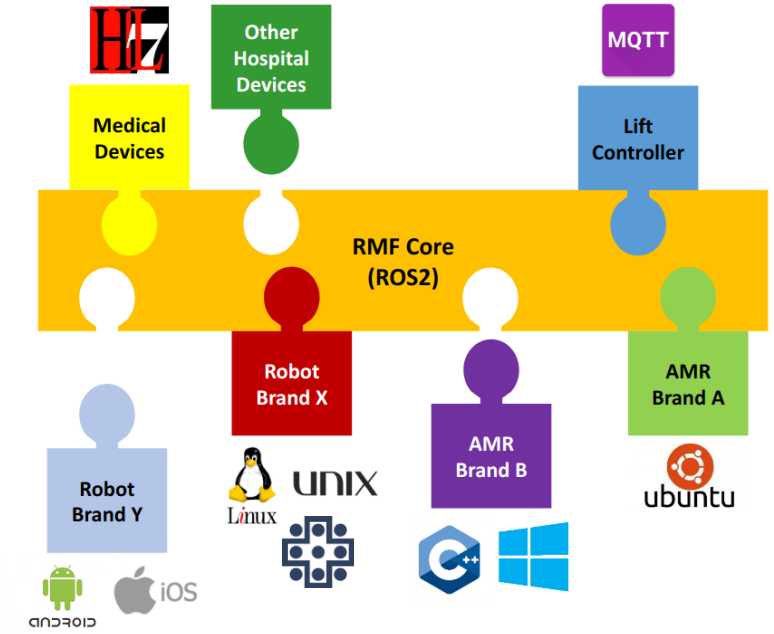
Adds intelligence to the system through resource allocation and by preventing conflicts over shared resources.



RoMi-H uses ROS 2, but RoMi-H is not ROS / ROS 2

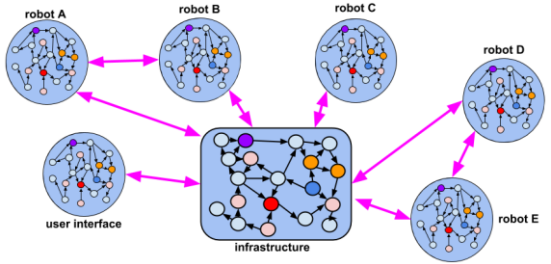
- Robotic Operating System (ROS 2) was adopted for the building of RMF Core.
- System architecture does take advantage of the nature of ROS

  Designed to be distributed and modular, ROS consists of a collection of tools, libraries and conventions to encourage collaborative robotics software development across a wide variety of robotic platforms.
- ROS 2 uses OMG's Data Distribution Service ("DDS") as the underlying communications standard… but this is selectable/changeable.

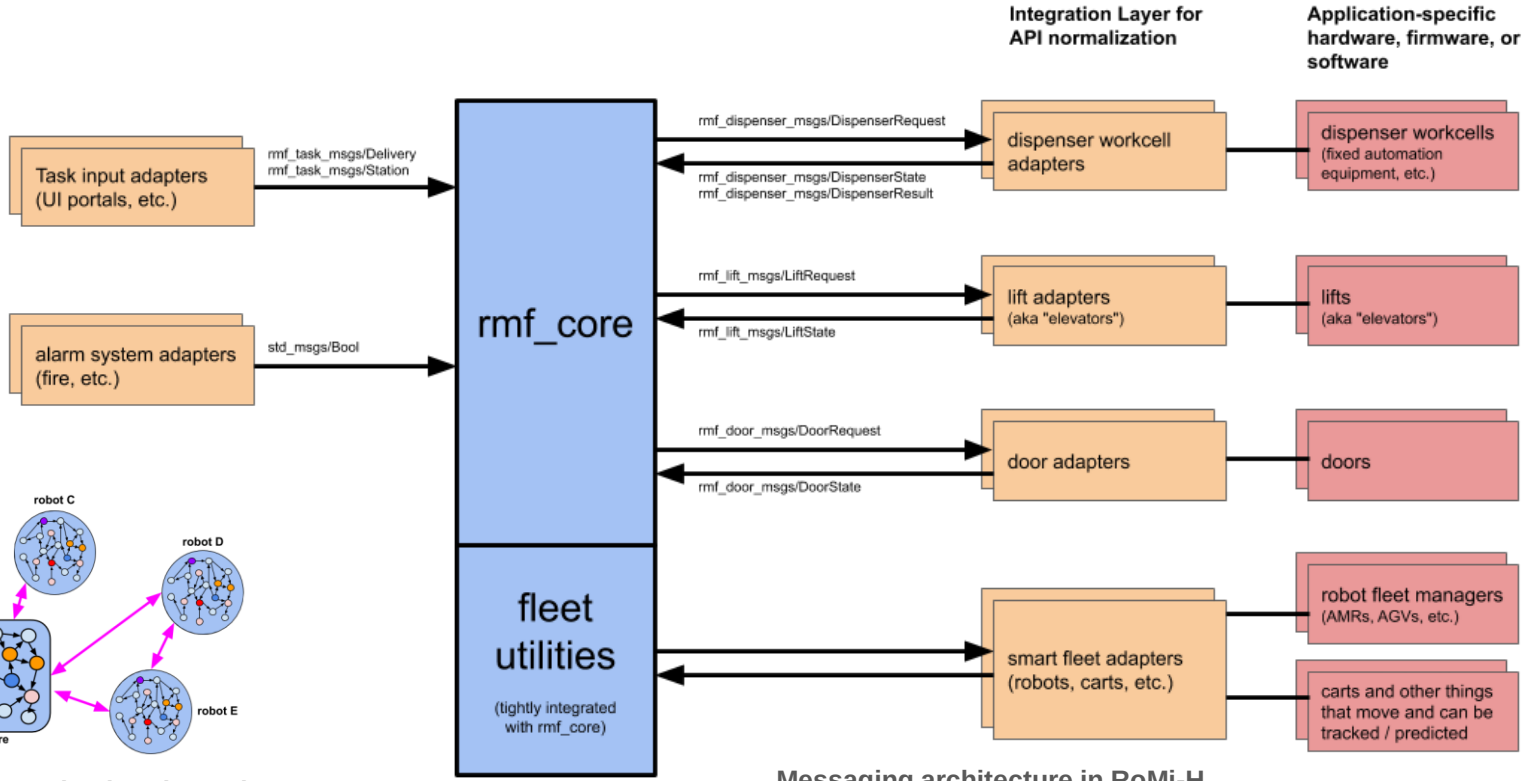


http://github.com/osrf/rmf_core

RoMi-H Simplifies & Standardizes Messaging



Systems of Systems Synthesizer (SOSS)



Messaging architecture in RoMi-H

http://github.com/osrf/traffic-editor

How much control is needed? It's complicated.

Increasing throughput potential

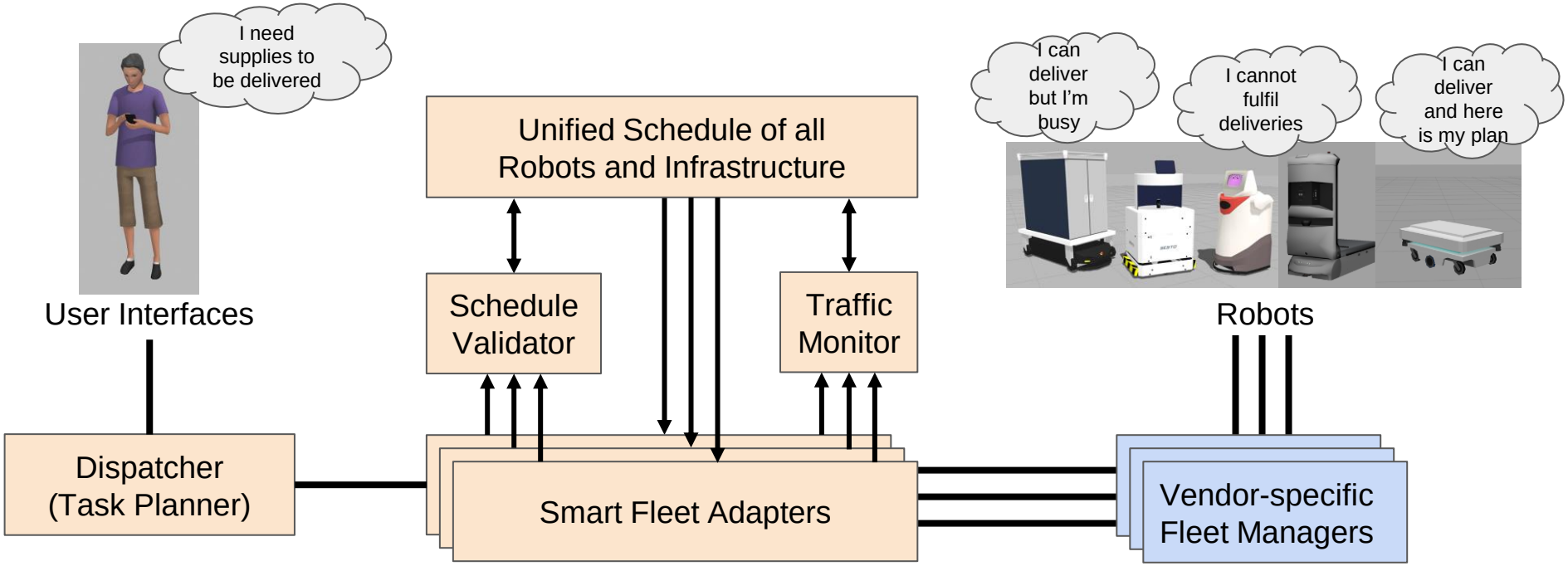
Fleet Manager API features	Potential benefits
"paths": robot waypoint control	Reduce stoppages, increase interaction efficiency. Deal gracefully with the unexpected.
"traffic light": robot pause, resume	Spatio-temporal separation of robots can often be achieved.
"read-only": robot locations, destinations	Unified dashboard for operators. Data can allow other robots to avoid conflicts with this fleet.
no fleet API ☹	None. Fleets cannot coordinate with each other at all to avoid or resolve conflicts.





http://github.com/osrf/rmf_core

RoMi-H Provides Flexibility in Multifleet Tasking

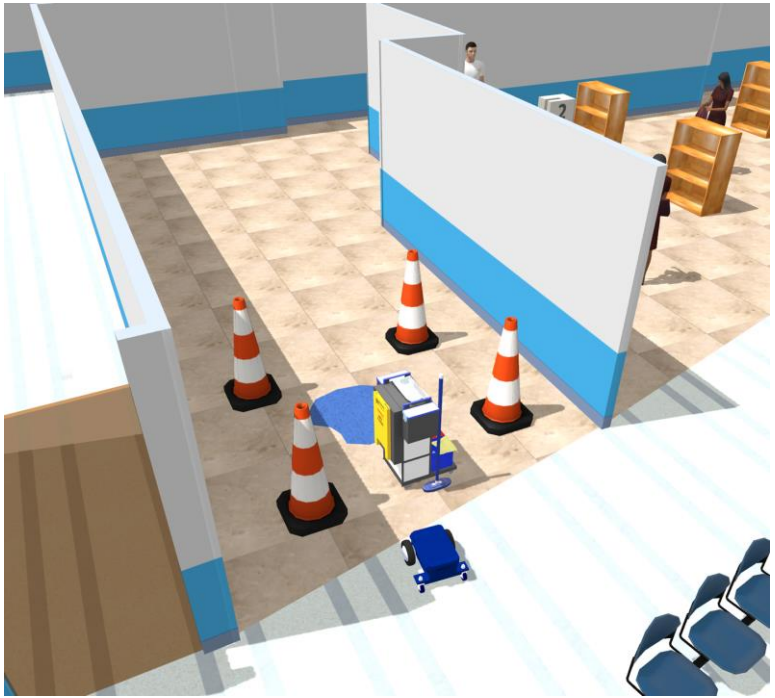


RoMi-H predicts and resolves conflicts

Predicted plan for a robot may change given environmental variability

- Human traffic
- Unknown obstacles
- Busy/faulty lifts or doors
- Change in original intention
- Emergency stop or alarms

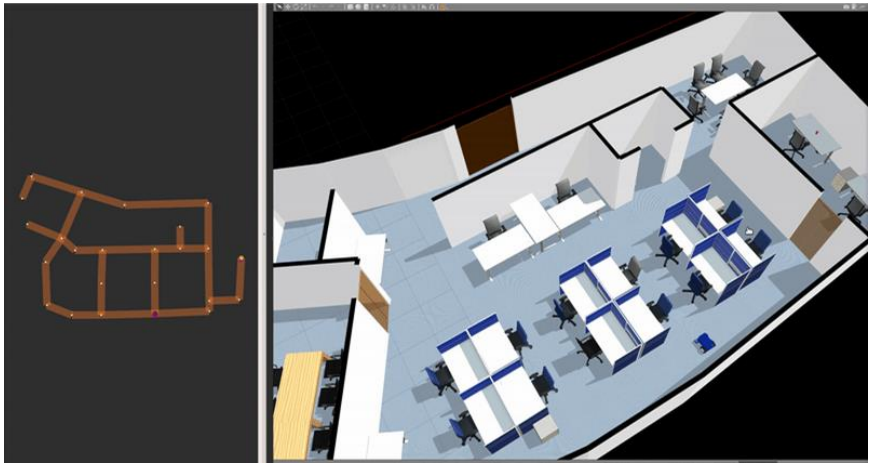
RMF continuously monitors changes in the Unified Schedule and appropriately reports conflicts to Smart Fleet Adapters for resolution.



http://github.com/osrf/rmf_demos

Testing in simulation is extremely important

- Using the existing Gazebo worlds, the code running in simulation is identical to that running in the actual hardware!
- Time saving - free sample environments and assets exist to test your software and visualize the solution. CHART environment being released soon!
- Testing / Tuning
  - Extended operation duration
  - Scalability
  - Debug edge cases
  - Vendor integration
  - Algorithms



Loop Request Scenario: Robots loop between waypoints while resolving conflicts in their paths and interacting with doorways

This is a physics-based simulation running the actual rmf_core software!

Documentation, Tutorials and General Help

- Documentation
  - Start here - https://osrf.github.io/ros2multirobotbook/
  - Installation of essentials - https://osrf.github.io/ros2multirobotbook/#installation-of-the-rmf-essentials
  - Individual repositories - https://github.com/osrf/rmf_core, https://github.com/osrf/free_fleet, etc.
- Tutorials
  - RMF Demos - https://github.com/osrf/rmf_demos
  - Includes example worlds of office, airport and soon will include healthcare
- General Help
  - CHART is a great place to start!
  - For any of the open source code, GitHub is a fast and efficient tool

How can we use RoMi-H?

How will system integrators use RoMi-H

Step 1
Develop device adapters

Adapters for lift/doors, other shared infrastructure resources

Adapters for existing & new AMR fleets

Other adapters/integrations (e.g. Medical Device, Robot Arm Workcells, Health IT systems) as required

Step 2
Develop applications

Application system containing business logic based on user story & workflow

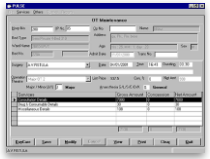
Configurable UI, Visualization tools & dashboards

Some examples of adapters created and tested with RoMi-H

AMR Fleet Adapters

CSSD and OT workcells; Robotic Arm

Health IT system
- **OTMS**
- **Ward Nurse UI**



RFID authentication system

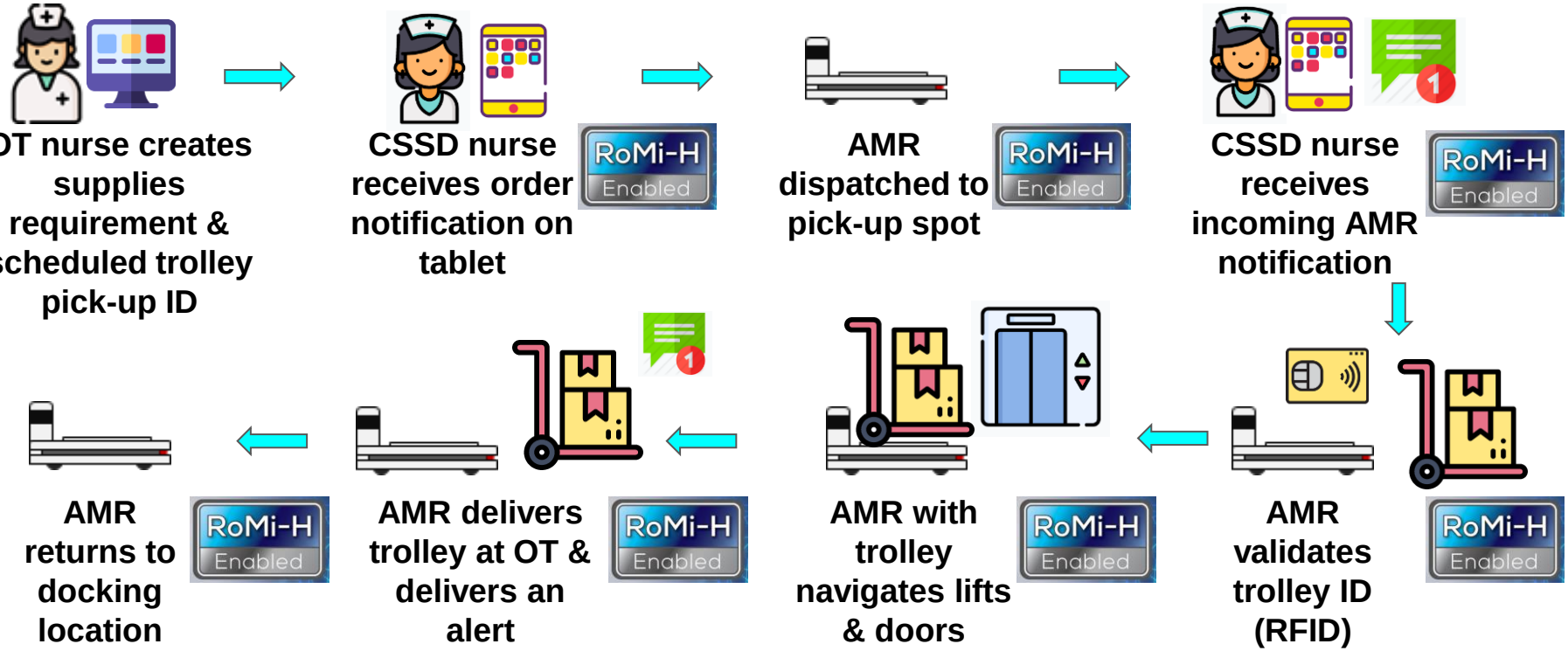
Bolt-on kit for trolley bed

Medical Devices
- **VSM Machine**
- **Infusion Pump**

Inventory location tracking system adapters

Infrastructure Devices
- **Fire Alarm**
- **Lifts / Doors**

Illustrative future user story: CSSD to OT delivery



How does RoMi-H make a delivery use-case easier

Without RoMi-H

- Manual coordination between nurses at both ends
- User-interfaces that do not talk to each other
- No communication between different systems (AMRs with OTMS, CSSD)
- Deadlock between different types of AMRs

RoMi-H enabled

- User interfaces for both OT & CSSD nurse linked via RoMi-H
- Notifications, status updates to multiple UIs
- Translate multiple message formats
- Dispatching multiple OEM AMRs, navigating lifts/doors

What’s the future beyond healthcare

Sample use-cases

Transport

- Visualize multiple robot fleets on a single dashboard
- Coordinate same-genre and Multi-genre robots

Manufacturing / Logistics

- Deconflict and lift-sharing of robots and pallet trucks
- Maneuver robots in narrow aisle in warehouses and manufacturing floor

Retail malls/commercial buildings

- Access multi-level buildings via lift/ doors
- Coordinate multi fleet robots for cleaning and delivery
- Purchase apps

Hospitality

- Coordinate same-genre and Multi-genre robots