Planning of mobile assistant units in assembly lines for performing material supply operations

ERF 2016, March 21, 2016, Ljubljana

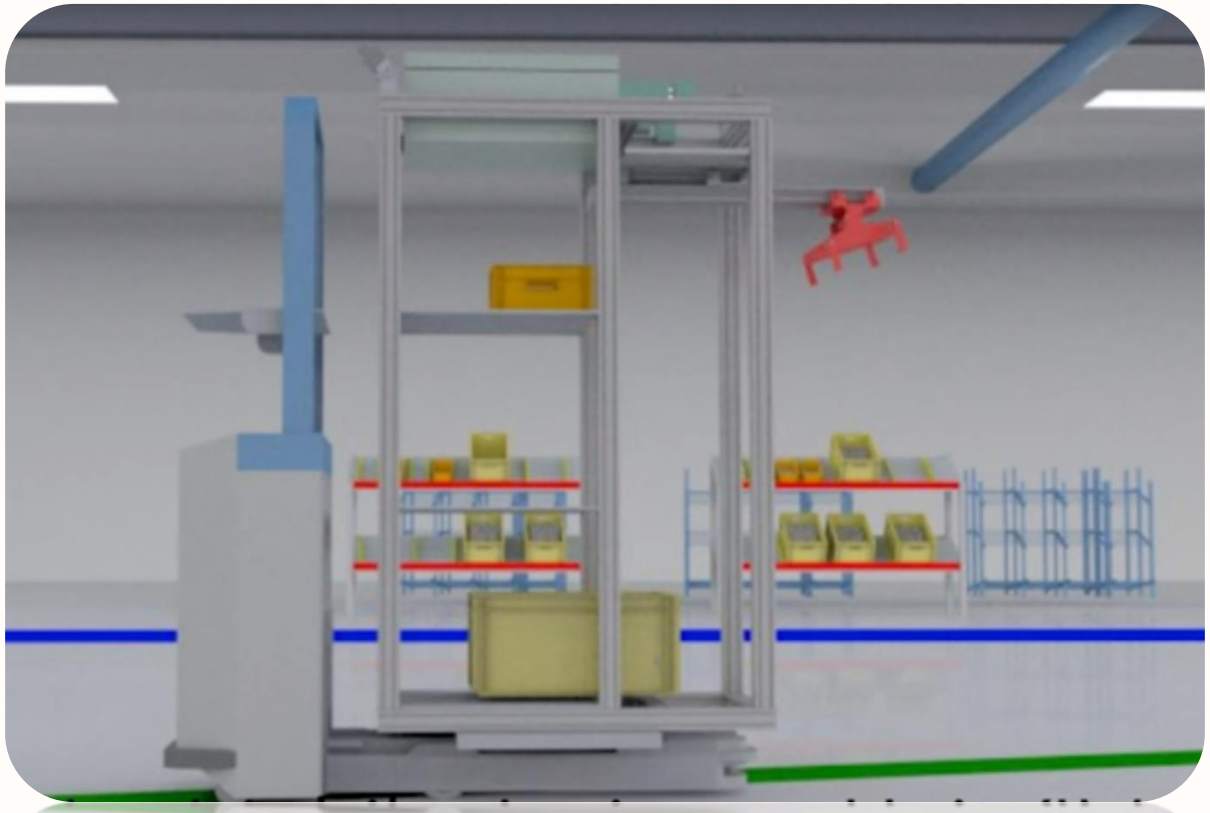
Mrs. Niki Kousi

Laboratory for Manufacturing Systems and Automation
University of Patras
Greece

Contents

Intelligent Intralogistics Concept

- Intralogistics Mobile Assistant Units (IMAUs)

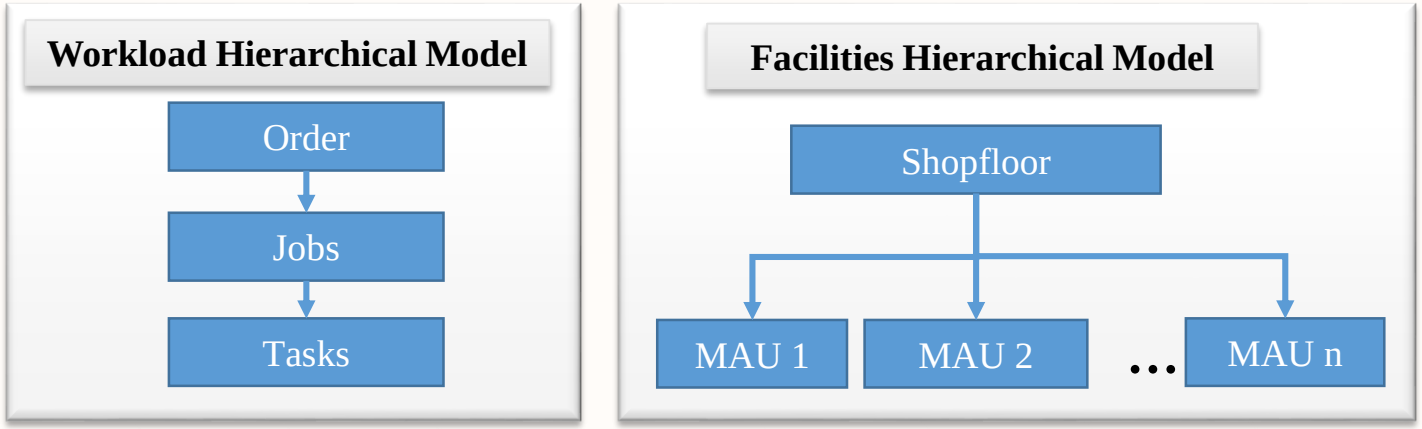


ROBO-PARTNER IMAU Concept video

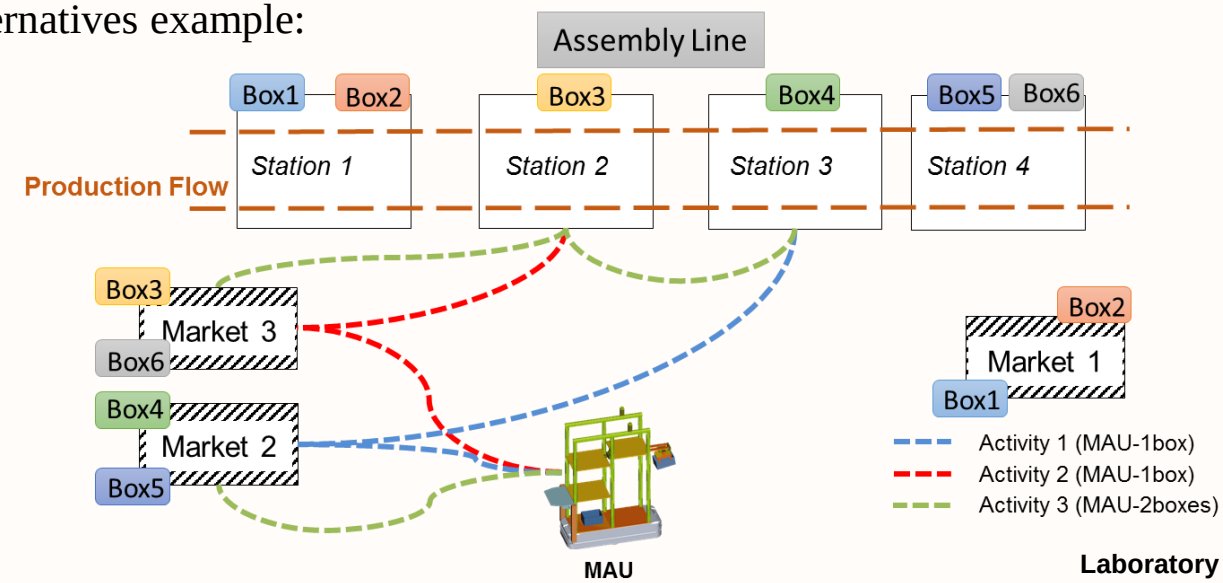
Laboratory for Manufacturing
Systems and Automation

Planning of material supply operation

- Hierarchical Modelling



- Task alternatives example:



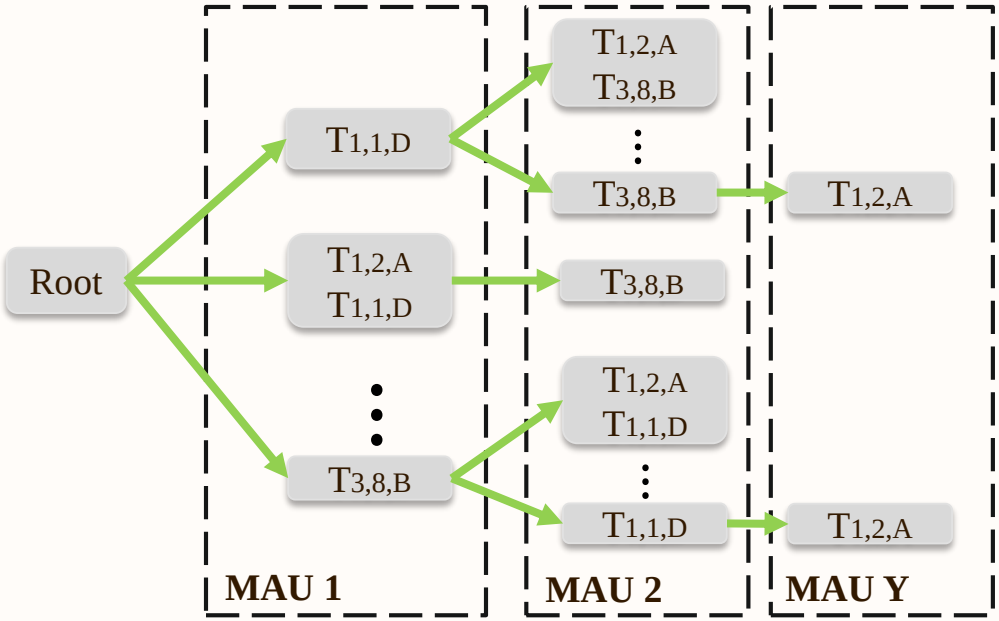
Laboratory for Manufacturing Systems and Automation

LMS

*G. Michalos, K. Kaltsoukalas, P. Aivaliotis, P. Sipsas, A. Sardelis, G. Chryssolouris, "Design and simulation of assembly systems with mobile robots", CIRP Annals-Manufacturing Technology, Available Online 2014

Formulation of search problem

- Boxes needing replacement = 3, Available MAUs in the shop floor is Y



$T_{i,j,k}$:
- i = destination station id
- j = consumable box id
- k = consumable box type

- Node of a tree ▸▸ Group of tasks to be performed by the MAU
- Branch of tree ▸▸ Complete schedule (tasks alternative)
- Operations precedence relations are satisfied
- MAUs suitability constraints define candidate resources for each task

*G. Michalos, P. Sipsas, S. Makris, G. Chryssolouris, "Decision making logic for flexible assembly lines reconfiguration", Robotics and Computer-Integrated Manufacturing, Available Online (2015)

**G. Michalos, S. Makris, D. Mourtzis, "An intelligent search algorithm-based method to derive assembly line design alternatives", International Journal of Computer Integrated Manufacturing, Volume 25, No.3, pp.211-229(2012)

Laboratory for Manufacturing Systems and Automation
LMS

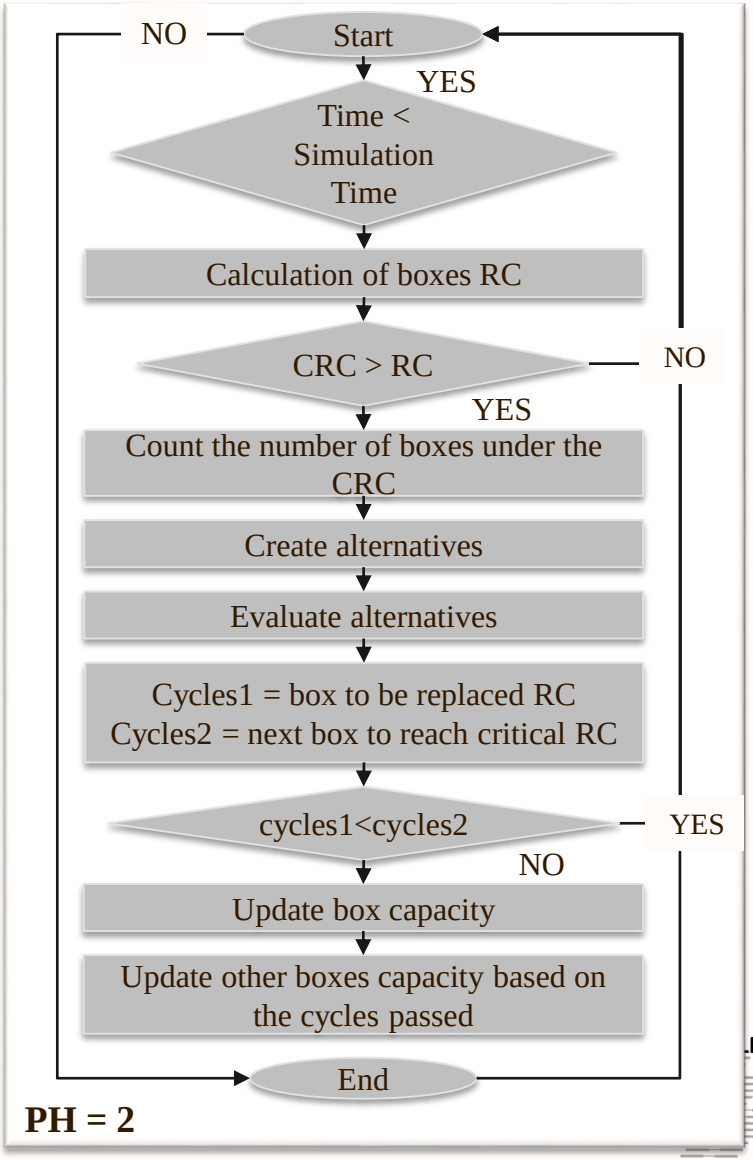
Planning Rules & Performance criteria

Planning rules:

- Remaining Cycles for part depletion (RC)
  - ✓ Represents the cycles that **each box can serve** before its depletion
  - ✓ Critical Remaining Cycles (CRC) - **threshold**
- Planning Horizon (PH)
  - ✓ Integer value – **1 to max number for boxes** that the MAU can carry simultaneously
  - ✓ Checks if the MAU should **wait** for the **next box** to get under the threshold

Performance criteria:

- Distance travelled from the MAU for each alternative
- Time Required for transportation (t_t)



*Niki Kousi, George Michalos, Sotiris Makris, George Chryssolouris, "Short – term planning for part supply in assembly lines using mobile robots", 6th CIRP Conference on Assembly Technologies and Systems (CATS) – Volume 44, pp.371-376(2016)

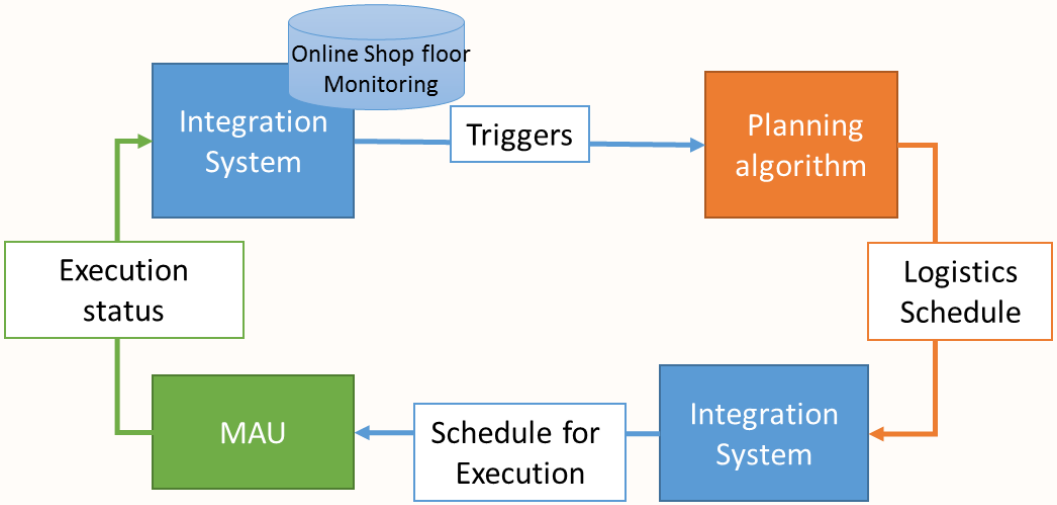
Case study

Rear wheel assembly line:

- 4 Product variants
- 4 Stations – 1.5 min cycle time / station
- 18 different consumable boxes
- 4 market areas

Rear Wheel group assembly line*

System Implementation Architecture:



Results:

PH	Parts entered	Production Volume	No of MAU transportation	No. of Rejections	Part depletion
PH = 1	1200 1200	995	56	205	28
PH = 3		1052	41	148	12

Laboratory for Manufacturing Systems and Automation

LMS

*Source: http://www.nelman.es/servicios.html

Conclusions and Outlook

Conclusions:

- Tailor the **characteristics of different MAUs** (number of shelves, dimensions) through the PH variable
- Adjust **the decision making process** in order for the multiple variants (e.g. number of boxes) to be considered by the PH variable
- Achieve a **higher production volume** of the system,
- **Reduce part depletion** occurrences and
- **Reduce the MAU's travelling distance**, leading to an increased utilization of these resources and to a reduction in the idle time.

Outlook:

- Implementation of **intelligent search algorithms**
- **Integration** of planning algorithm with **MAUs control** system
- **Connection** with **shop floor** monitoring systems

*Niki Kousi, Spyridon Koukas, George Michalos, Sotiris Makris, George Chryssolouris, "Service oriented architecture for dynamic scheduling of mobile robots for material supply", 5th CIRP Global Web Conference Research and Innovation for Future Production (CIRPe) 2016– Accepted for publication

**N. Papakostas, D. Mourtzis, S. Makris, G. Michalos, G. Chryssolouris, "An agent-based methodology for manufacturing decision making: a textile case study", International Journal of Computer Integrated Manufacturing, Volume 25, No.6, pp.509-526 (2012)

Acknowledgements

ROBO-PARTNER

Seamless Human-Robot Cooperation
for
Intelligent, Flexible and Safe Operations
in the
Assembly Factories of the Future

http://www.robo-partner.eu.eu/

This research has been partially supported by the research EU FP7 project "ROBO-PARTNER – Seamless Human-Robot Cooperation for Intelligent, Flexible and Safe Operations in the Assembly Factories of the Future" (Grant no. 608855) funded by the European Commission.

THANK YOU!

Laboratory for Manufacturing Systems and Automation
University of Patras
Tel: +30-2610-997262

www.lms.mech.upatras.gr
kousi@lms.mech.upatras.gr