A Cyber Physical Test Bed for Advanced Manufacturing

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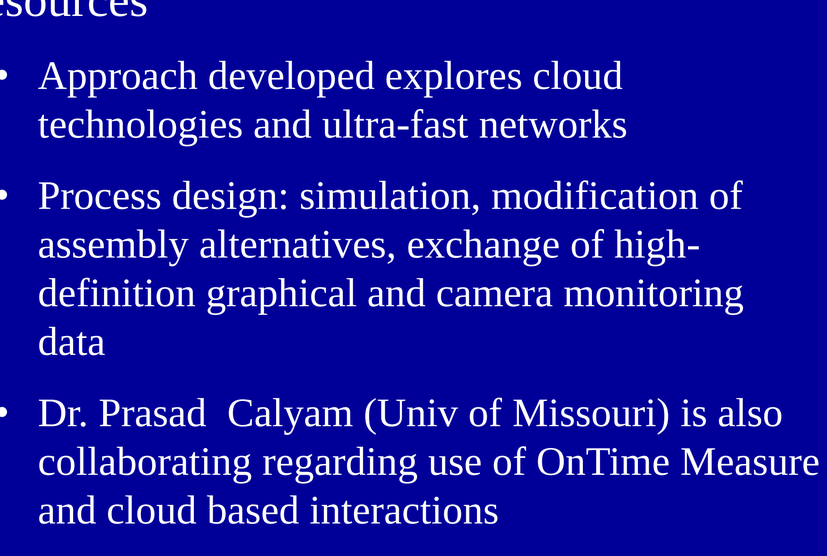
Summary

- Development of a Next Generation cyber physical framework for advanced manufacturing using Ultra-fast networks and GENI infrastructure
- Domain: micro devices assembly (MDA)
  - Framework developed enables collaboration of globally distributed software and manufacturing resources
  - Phase 1: Cyber physical interactions within US
  - Phase 2: Interactions between cyber physical resources in US and EU
- Funded by NSF CICE (CNS)

Background

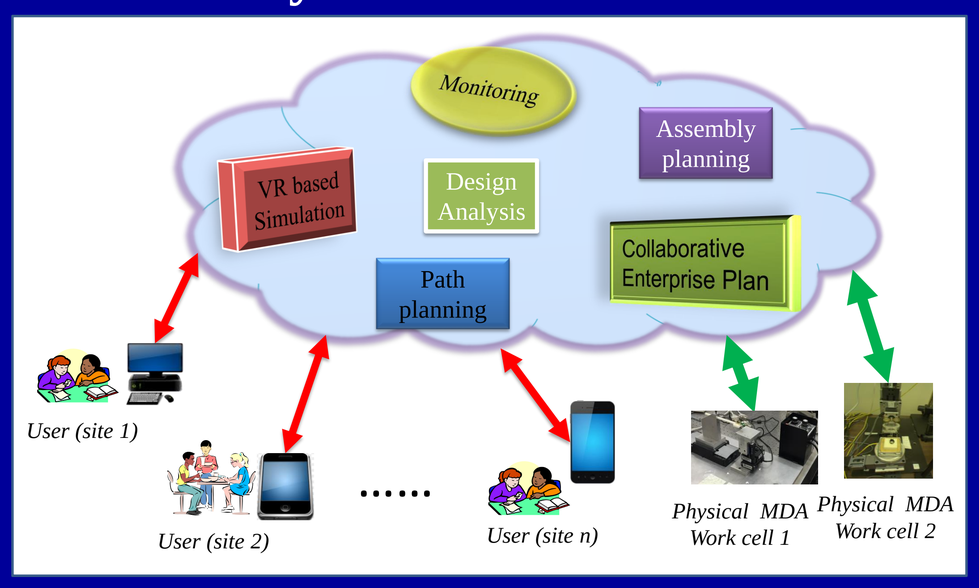
- In MDA, the resources and tools to accomplish the product life cycle activities are not co-located
- Need: Develop an 'agile' framework involving collaboration of cyber physical resources
  - Approach developed explores cloud technologies and ultra-fast networks
  - Process design: simulation, modification of assembly alternatives, exchange of high-definition graphical and camera monitoring data
  - Dr. Prasad Calyam (Univ of Missouri) is also collaborating regarding use of OnTime Measure and cloud based interactions

Virtual Assembly Environments



Close-up View of a Virtual Work Cell

Framework for Cyber Physical Test Bed



- Distributed partners will posses variety of cyber and physical resources

GA based assembly planning Result Compare

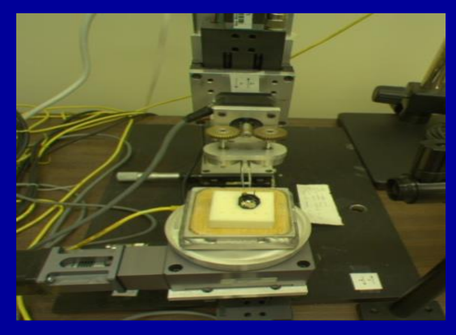
Parts number	Category	Converging Iteration	Result
20	GA	76353	1014.466714
	Hybrid GA	19130	1014.466714
50	GA	168514	2120.624217
	Hybrid GA	74305	2120.624217
100	GA	331273	8203.614765
	Hybrid GA	207061	8203.614765

- Software modules in test bed reflect diversity and heterogeneity of resources
- GA based planning, Greedy algorithm based planning modules
- Modules for path planning, generation of assembly instructions

Cyber Physical Life Cycle

- Overall interactions were modeled and designed using information modeling approaches (both IDEF-0 and eEML modeling languages)
  - Upload/input target designs
  - Generate Assembly Plans
  - Generate Path Plans
  - Simulate /Analyze Assembly alternatives
  - Perform physical assembly
  - Monitor assembly / provide feedback

Physical Assembly

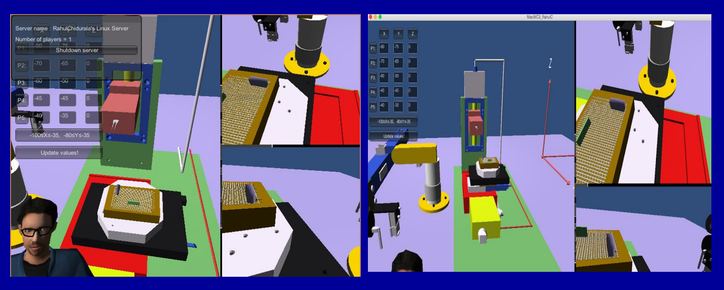


One of the Physical Work Cells

A sample part comprising of meso/micron sized components

Interim Results

- Interactions and Demonstrations were conducted successfully in Test Bed
  - Resources in Stillwater (OK) , Madison(WI) and Tulsa (OK) Experiments between resources in the US and European Union have been competed.



Assembly Analysis using Virtual Environments (Tulsa and Stillwater, OK)

Publications

❖ Cecil, J., Kumar, M. B. R., Lu, Yajun, Basallali, V. (2015). A review of micro-devices assembly techniques and technology. The International Journal of Advanced Manufacturing Technology, 1-13.

❖Lu, Yajun, and J. Cecil. "An Internet of Things (IoT)-based collaborative framework for advanced manufacturing." The International Journal of Advanced Manufacturing Technology (2015): 1-12.

❖ J. Cecil, Yajun Lu, A Next Generation collaborative framework for Micro Devices Assembly, 2015 ASME, Houston, Nov 2015.