

# Time-Critical Resource Management in Dynamic BM/C2 Systems

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# Problem

- **Time-critical resource management for dynamic BM/C2 (and many other) systems falls in the “No Man’s Land” between**
  - **classical real-time computer scheduling and**
  - **other scheduling fields such as deadline-based job shop scheduling.**
- **The concepts and techniques on either side of this divide are not dynamic and asynchronous, or are for the wrong time scales, etc.**
- **This makes time-critical BM/C2 resource management more expensive and less effective.**

# Background

- **BM/C2 (and many civilian) systems have extremely challenging machine-to-machine resource management problems.**
  - **Multiple resources at any given level (e.g., in a sensor or weapons platform), and across levels (e.g., in a theater) of the system**
  - **Multiple conflicting concurrent needs for them – targets of opportunity to be attacked or saved**
- **Both resources and needs have numerous dynamic constraints to be satisfied.**
- **In particular, some of the system's actions are time-critical, typically in time scales of a second to hours.**

# Objective

- Focus on using *time/utility functions*
  - empirically proven effectiveness and adaptability at sensor and network centric levels in BM/C2 systems
  - but lack of formalism, methodology, and software tools limits ease of use and confidence
- Adapt and extend constraint programming and constraint-based scheduling's formalisms, methodologies, and (COTS) software tools – add support for
  - stochastic properties
  - time/utility functions
- Develop algorithms for the BM/C2 seconds-to-hours time scales

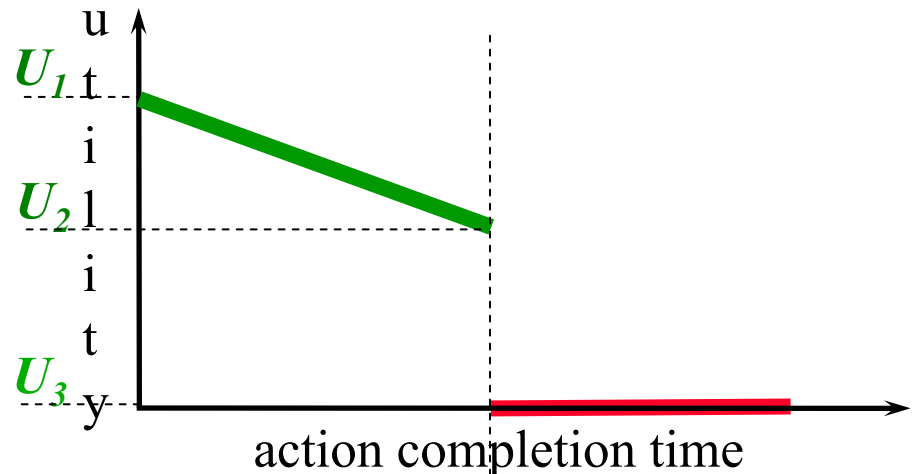
# Activities

- **Formalism**
  - Exploring potentially applicable formalisms from fields such as constraint-based scheduling, scheduling theory, and utility functions
- **Proof-of-concept software tool**
  - Working with COTS vendor ILOG to adapt and extend their constraint-based Scheduler product to
    - stochastic cases
    - time/utility function constraints
- **Technology demonstration and transition**
  - Collaborating with NASA JPL, which has decided to use time/utility functions in their new Mission Data System, initially for the Mars Science Lab (launch date 10/09)
  - Working with MC2A and MP-RTIP as candidate DoD transition opportunities

# Highlight

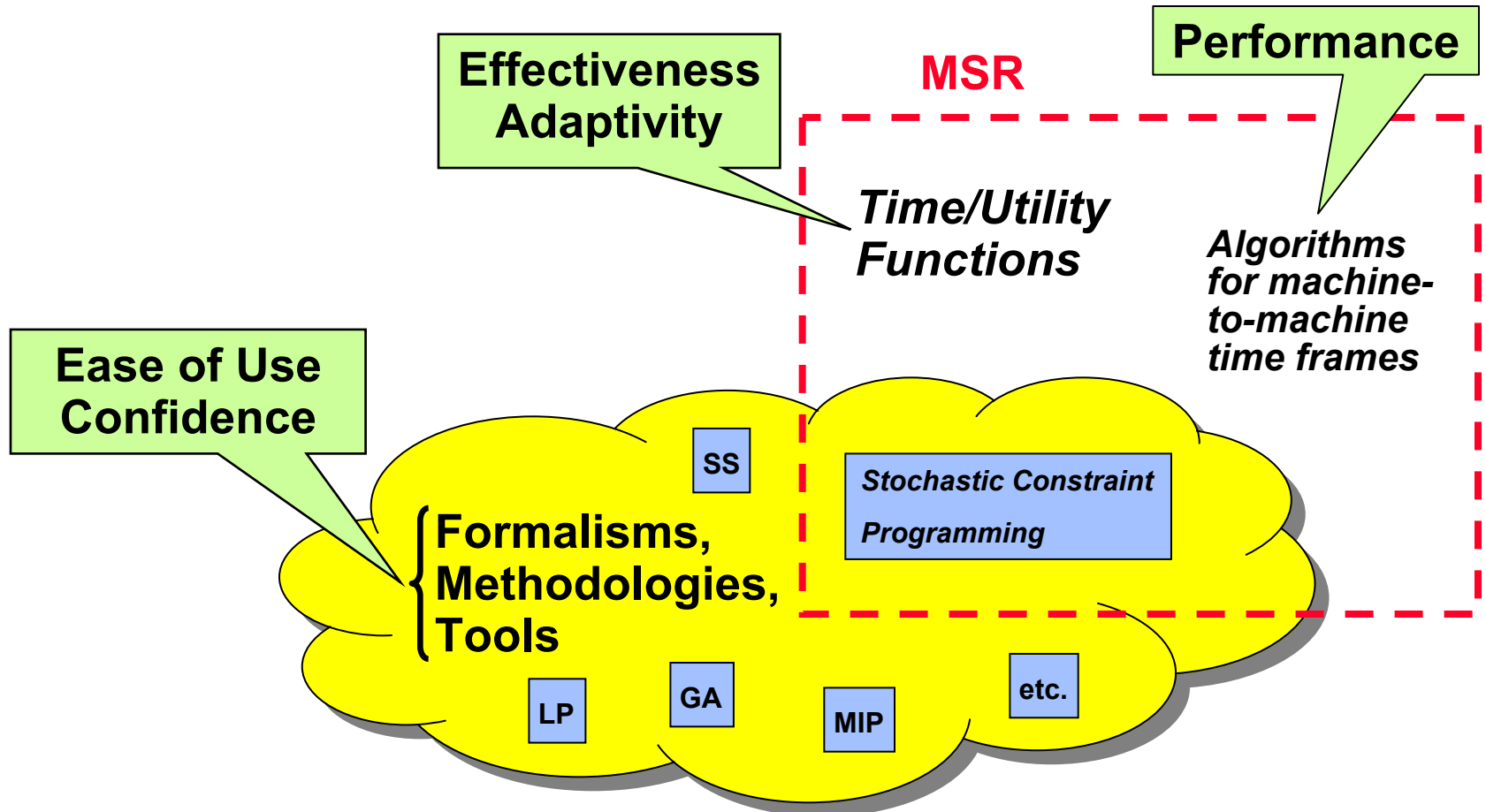
## Time/Utility Functions

- The utility to the system of completing an action is an application- or situation-specific function of when it completes.
- Actions are scheduled according to a discipline that maximizes their accrued (e.g., total) utility.
- More adaptive, natural, and expressive than priorities
- Higher computational cost, but can be low enough for BM/C2 time scales



*(Example from AWACS tracker ATD)*

# Highlight Technical Approach



Dependable, Effective, Dynamic Resource Management

# Impacts

- **Many DoD programs have essential and difficult time-critical resource management problems – e.g.,**
  - National Missile Defense
  - Advanced ISR Manager
  - Future Combat System
  - DD(X)
  - Global Broadcast Service
  - Space Based Infrared System
  - DARPA's Affordable Moving Surface Target Engagement system (AMSTE)
- **NASA JPL's Mission Data System will use this work.**
- **Civilian applications (e.g., industrial automation) have similar problems, and can provide a COTS venue.**

# Future Plans

## ■ Formalism

- Adapt and extend formalisms from fields such as constraint-based scheduling, scheduling theory, and utility functions

## ■ Methodology

- Adapt and extend methodologies from our own experience, from the formalisms, and from COTS vendor ILOG

## ■ Proof-of-concept software tool

- Adapt and extend the ILOG Scheduler product to stochastic cases, and to accommodate time/utility function constraints

## ■ Technology demonstration and transition

- Help JPL use time/utility functions in their new Mission Data System, initially for the Mars Science Lab (launch 10/09)
- Seek DoD transition opportunities – e.g., MP-RTIP, MC2A/C