A C2 Framework for Dynamic Battlespace Resource Management Based on Networking Concepts and a 'Post and Smart Pull' Approach

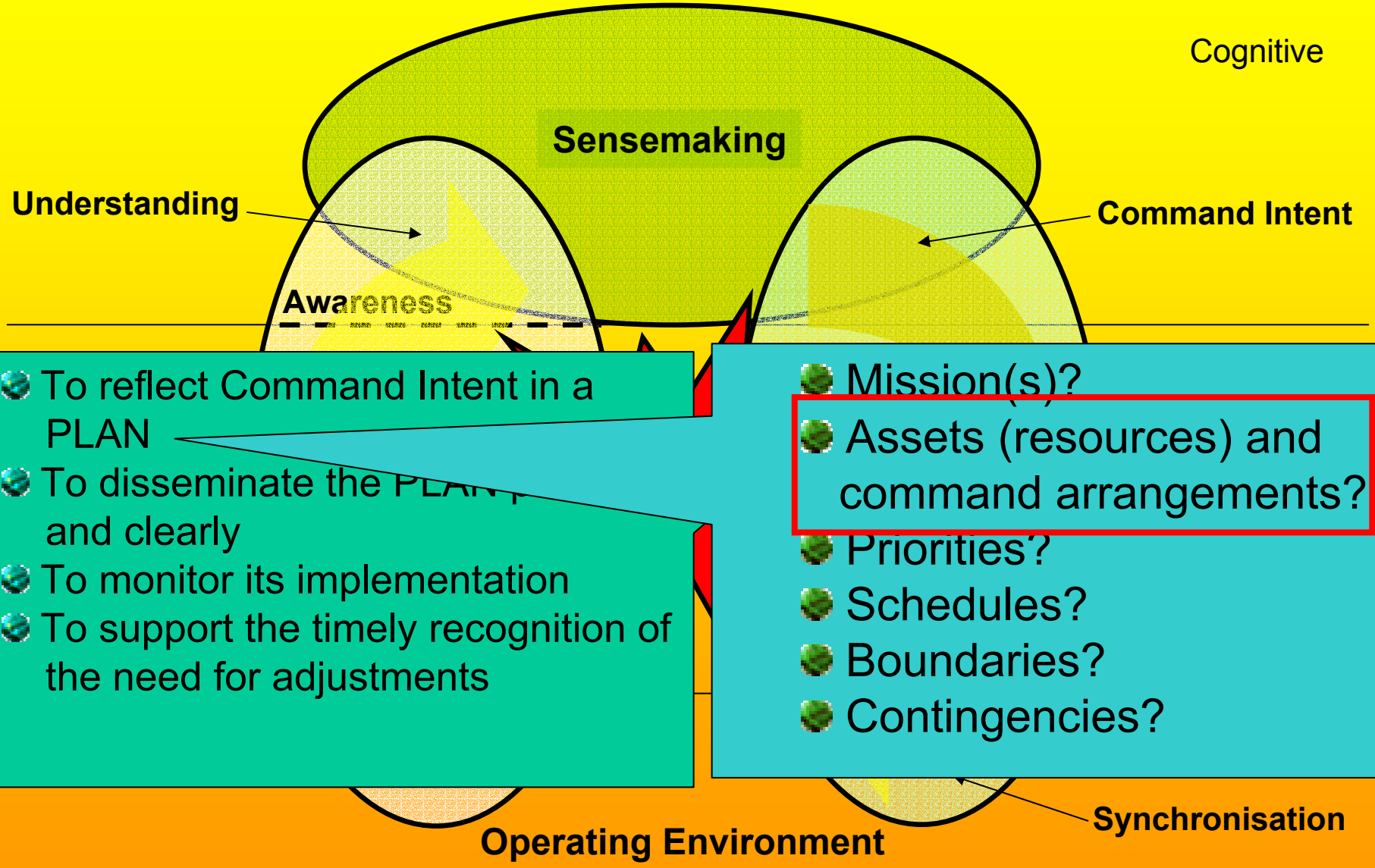
Prof. António Grilo[1, 2], Maj. P. Nunes [3],
Prof. M. Nunes[1, 2]

[1]INESC-ID/INOV, Portugal
[2]IST, Portugal
[3]CINAMIL, Portugal

Summary

- Introduction
- Motivation
- Web-based Battlespace Resource Management (WBRM)
- WBRM vs Networking Resource Management
- Conclusions
- Future Work

Introduction



- To reflect Command Intent in a PLAN
- To disseminate the PLAN [illegible] and clearly
- To monitor its implementation
- To support the timely recognition of the need for adjustments

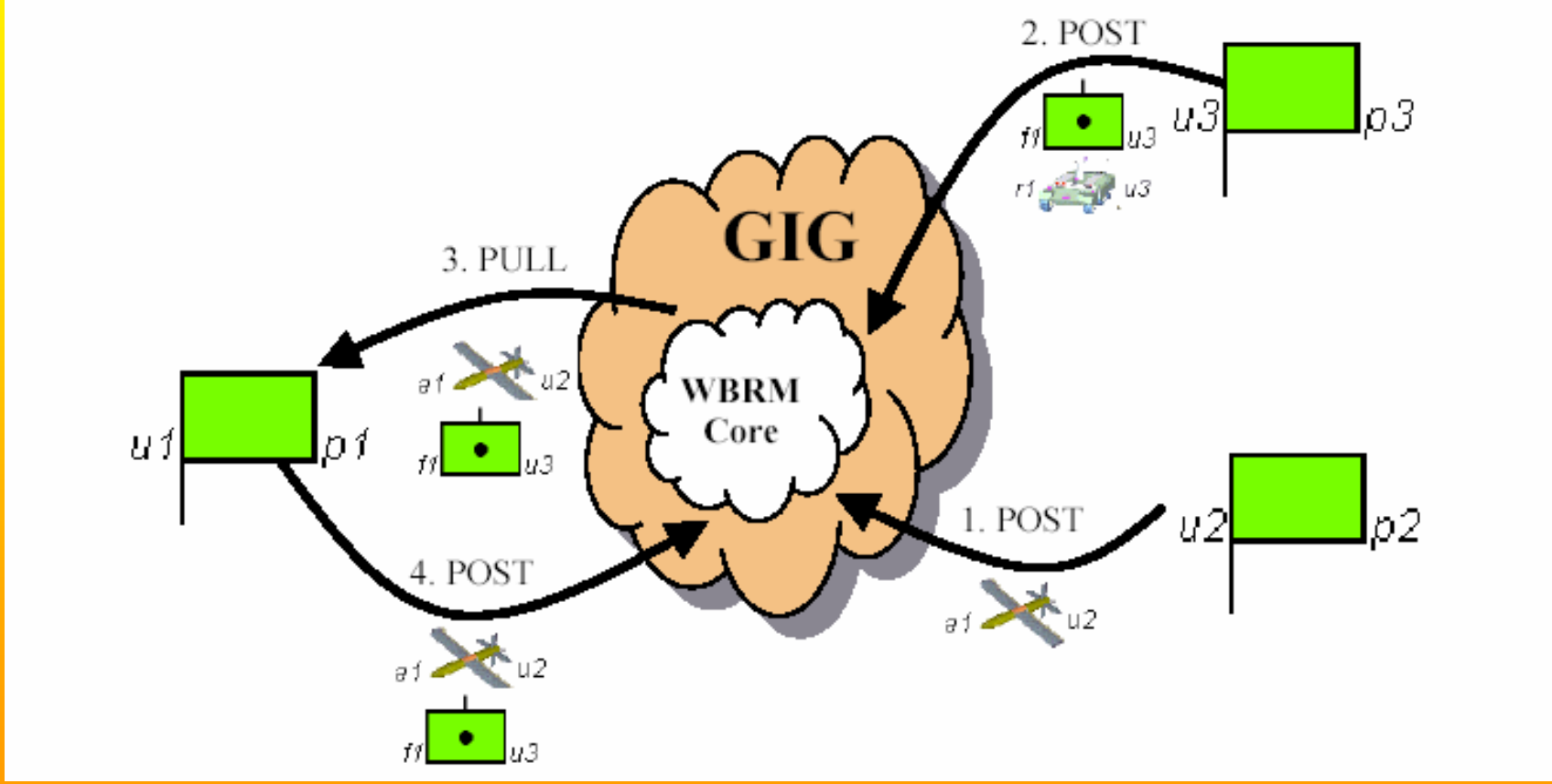
- Mission(s)?
- Assets (resources) and command arrangements?
- Priorities?
- Schedules?
- Boundaries?
- Contingencies?

(CCRP, Dr. David Alberts)

Motivation

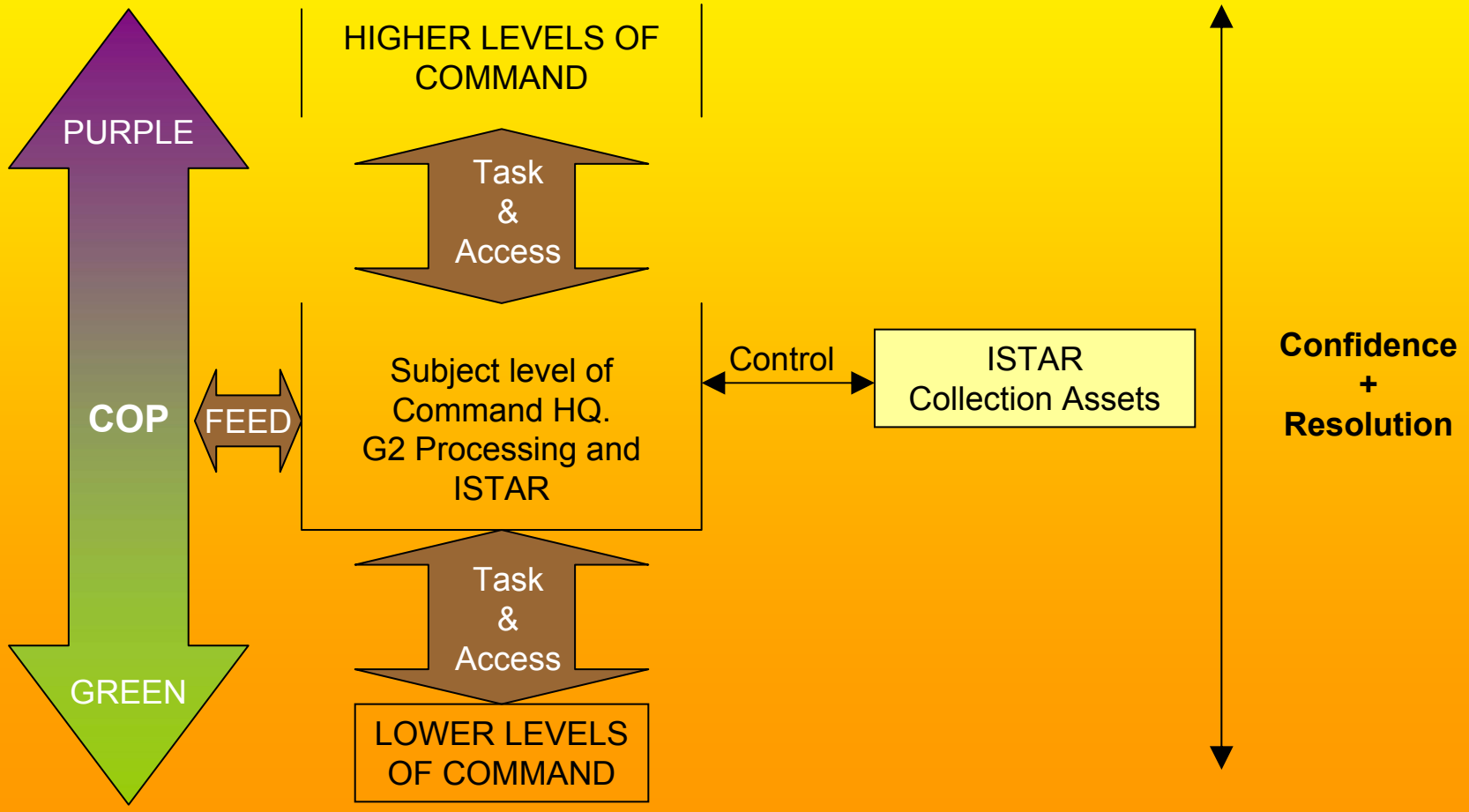
- Collaborative planning is time- and attention-consuming:
  - Re-planning and re-allocation of resources pays a price in terms of time and focus
  - Contingency planning can increase plan resilience and reduce the need for re-planning under manageable complexity and uncertainty
  - Overprovisioning of resources reduces the need for re-planning, but is resource inefficient
  - Overprovisioning may be avoided through the support of dynamic adjustment of resource assignments to missions

Web-Based Battlespace Resource Management (WBRM)



C4ISR trends urging WBRM (1)

- ISTAR C2 Model proposed by Graham Le Fevre (in D. Potts, *The Big Issue*).

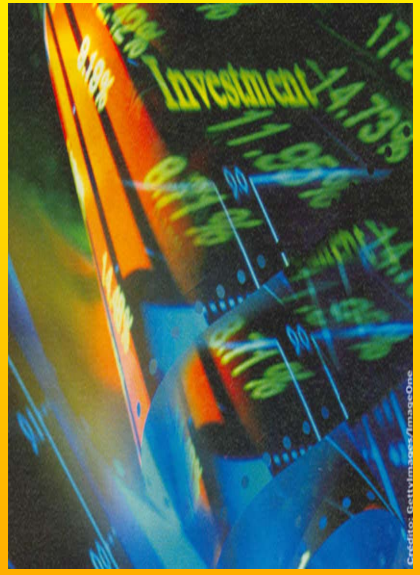


C4ISR trends urging WBRM (2)

- NCO with UAVs: USJFCOM exercise Extended Awareness 1 (see SIGNAL Magazine, April 2005).

WBRM Similarities with the e-Commerce paradigm

- Physical domain resources have only one instantiation (difficult replication)
- Physical domain resources are subject to expenditure/degradation over time
- Physical domain resources are subject to physical domain constraints and overheads



WBRM Requirements

- Transparency
  - *Post and smart pull* approach
- Flexibility
  - Support of different command arrangements
- Hierarchy mapping
  - Constraints on command arrangements based on echelon relationships
- Mission Package consistency
  - Support of atomic Mission Package *pull* transactions

Proposed WBRM Architecture

Resource Entity Record:

- Resource identifier
- Reference to the resource's supervision agent running in the WBRM Engine.
- Resource description.
- Resource's doctrine profile.
- Identifier of the decision entity that is its owner by default.
- Allocation and commitment status, including the identifier of the decision entity or entities to which it is currently allocated.
- Decision entity's currently assigned priority.

Supervision Agent:

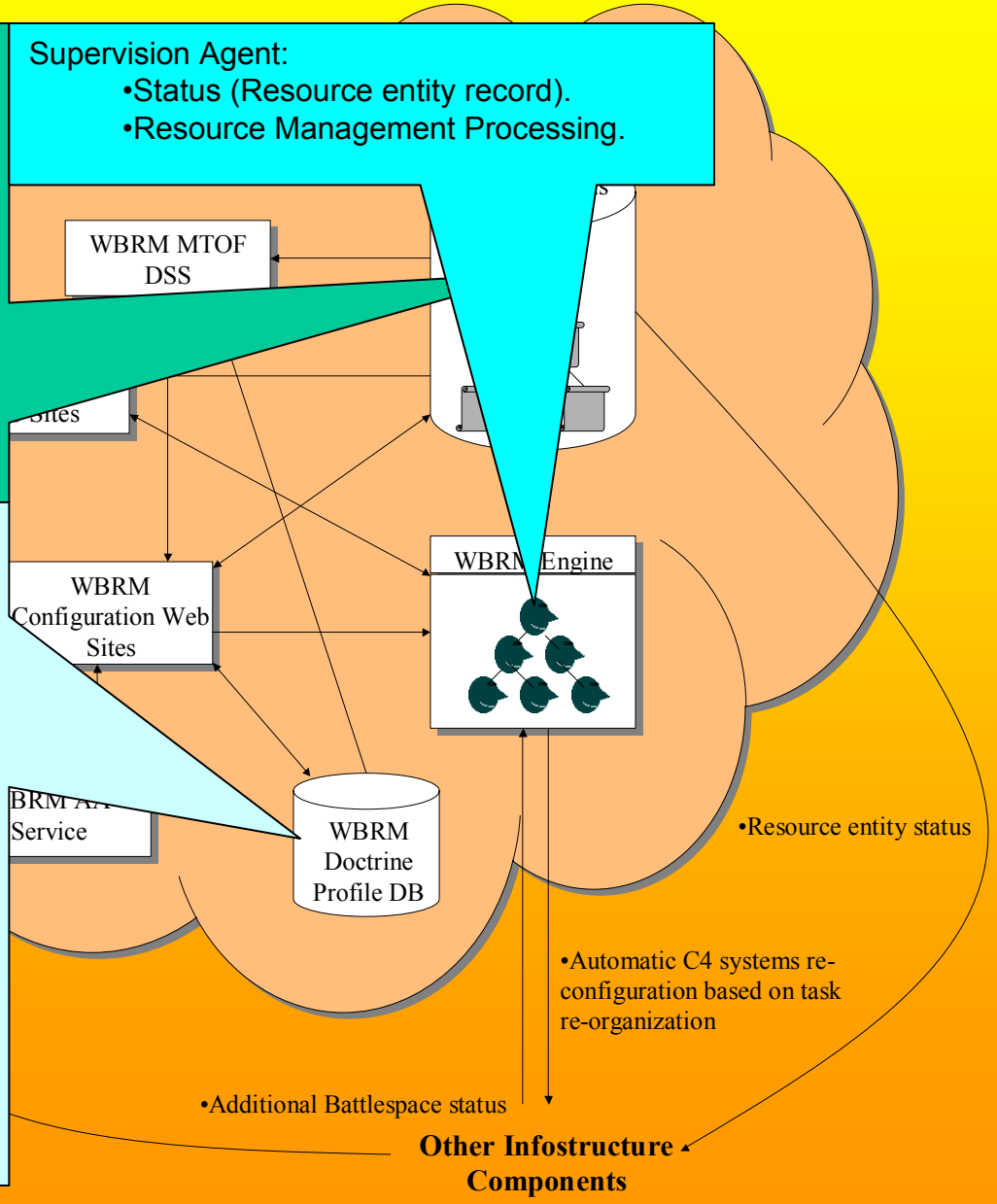
- Status (Resource entity record).
- Resource Management Processing.

Doctrine Profile:

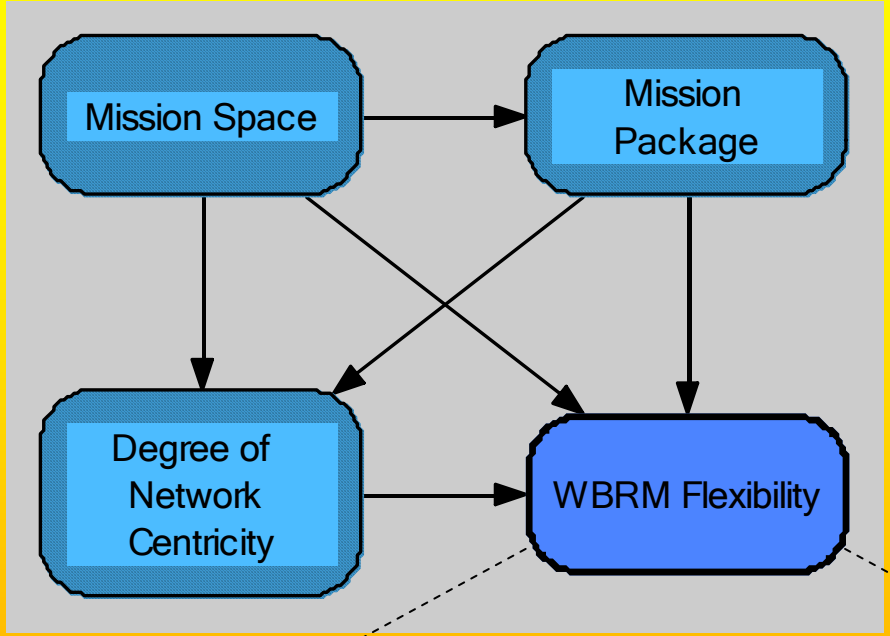
3. Rules that constrain the quantity and quality of resources that a specific decision entity can allocate.
4. Rules that constrain in a qualitative way the allocation of resources by a specific decision entity.

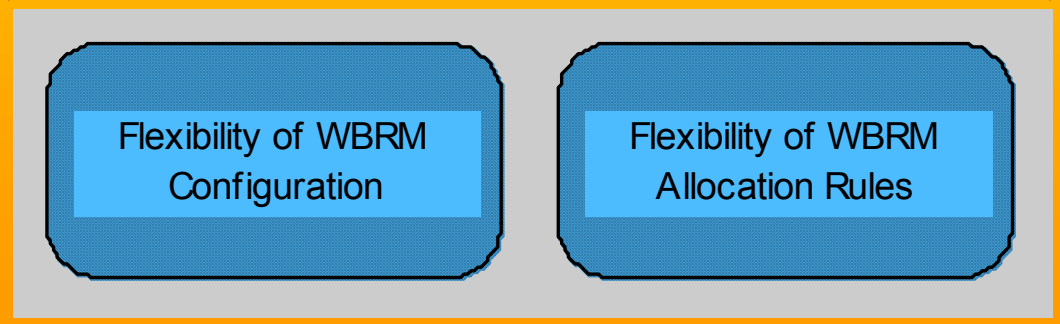
1. Rules that constrain in a qualitative way the allocation of a specific resource by decision entities.
2. Rules that constrain in a quantitative way the allocation of a specific resource by decision entities.

5. ROE



WBRM and Network Centricity

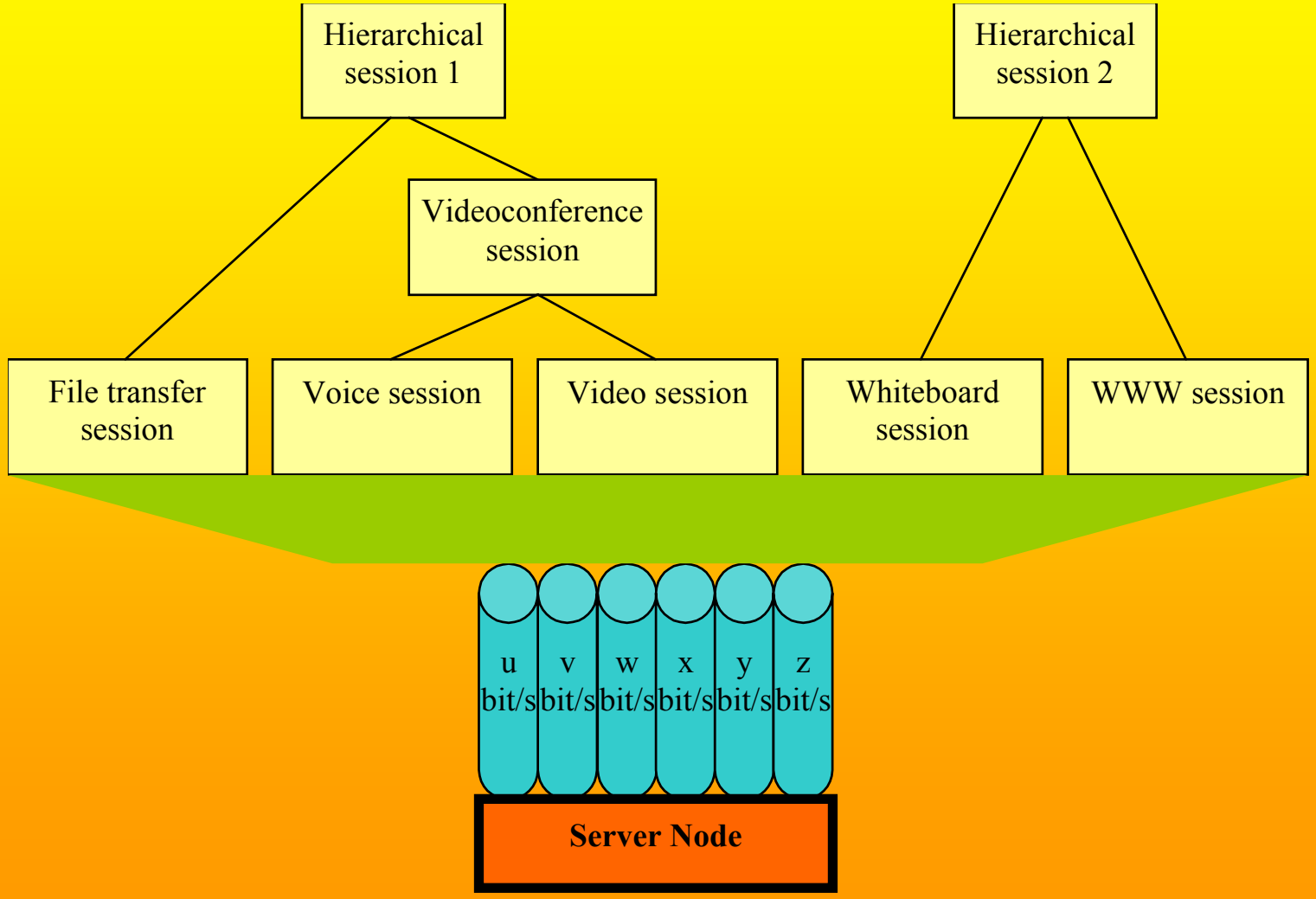




Summary

- Introduction
- Motivation
- Web-based Battlespace Resource Management (WBRM)
- WBRM vs Networking Resource Management
- Conclusions
- Future Work

Network Resource Management



Static vs Dynamic Allocation

- Static Resource Allocation
  - + Simple
  - + No management overhead
  - – Not adaptable to burstness/non-linearity
    - – Unable to deal with sudden bursts
    - – Waste of resources at times of inactivity
- Dynamic Resource Allocation
  - – More complex
  - – Increased management overhead
  - + Adaptive to activity changes

Network RM vs Battlespace RM (1)

Network	Battlespace
Successful data transmission	Successful mission accomplishment
Packet	Opportunity
User sessions	Decision entities
Channels	Battlespace resources that are not decision entities
QoS Policy	Battlespace resource management doctrine
Mean Rate	Average amount of resources/capability required by the decision entity at any time instant taking into account the expected probability, challenge and window of opportunities
Peak Rate	Maximum amount of resources/capability required by the decision entity at any time instant taking into account the expected probability, challenge and window of opportunities
Delay Bound	Window of opportunity

Network RM vs Battlespace RM (2)

Network	Battlespace
Packet/Session priority	Opportunity/Mission priority
Maximum Burst Duration	Maximum interval within which the maximum amount of resources/capability can be allocated
Packet Loss Ratio	Probability of missing an opportunity arising in the battlespace due to lack of available resources/capability
Maximum Transfer Unit	Expected maximum opportunity challenge, and by extension the respective resource requirement for successful seizure
Instant Data Rate	Amount of capability remaining in a battlespace resource

Network RM vs Battlespace RM (3)

- Battlespace Resource Management must deal with greater complexity:
  - Greater diversity of mission tasks, resource types, opportunities and contingencies.
  - Higher cost of error.
  - The challenge and window of an opportunity as well as the required amount of resources/ capability is more difficult to guess than packet size.
  - Which specific resources? For what purpose? For how long? At what cost?

Conclusions

- Web-based Battlespace Resource Management framework uses a *post and smart pull* approach.
- Dynamic Battlespace Resource Management is urged by current C4ISR trends to promote agility and efficiency through self-synchronization.
- An agent based reference model for the WBRM architecture is proposed.
- Supervision Agent processing may be inspired by network admission control and scheduling.
- Degree of WBRM flexibility should match the degree of network centricity.

Future Work

- Definition of a basic WBRM rule set.
- Definition of Supervision Agent algorithms.
- Agent-based simulation of WBRM:
  - In which conditions is WBRM feasible?
  - In which conditions is WBRM advantageous?
  - What is the desirable degree of WBRM flexibility?
- Refinement of the WBRM architecture.
- Development of basic demonstration applications for tactical level WBRM.

Acknowledgements

INSTITUTO SUPERIOR TÉCNICO
Universidade Técnica de Lisboa

LUSO-AMERICAN FOUNDATION
"A Portuguese Foundation for Development"

A C2 Framework for Dynamic Battlespace Resource Management Based on Networking Concepts and a 'Post and Smart Pull' Approach

Prof. António Grilo[1, 2], Maj. P. Nunes [3],
Prof. M. Nunes[1, 2]

[1]INESC-ID/INOV, Portugal
[2]IST, Portugal
[3]CINAMIL, Portugal