Distributed tasking algorithms

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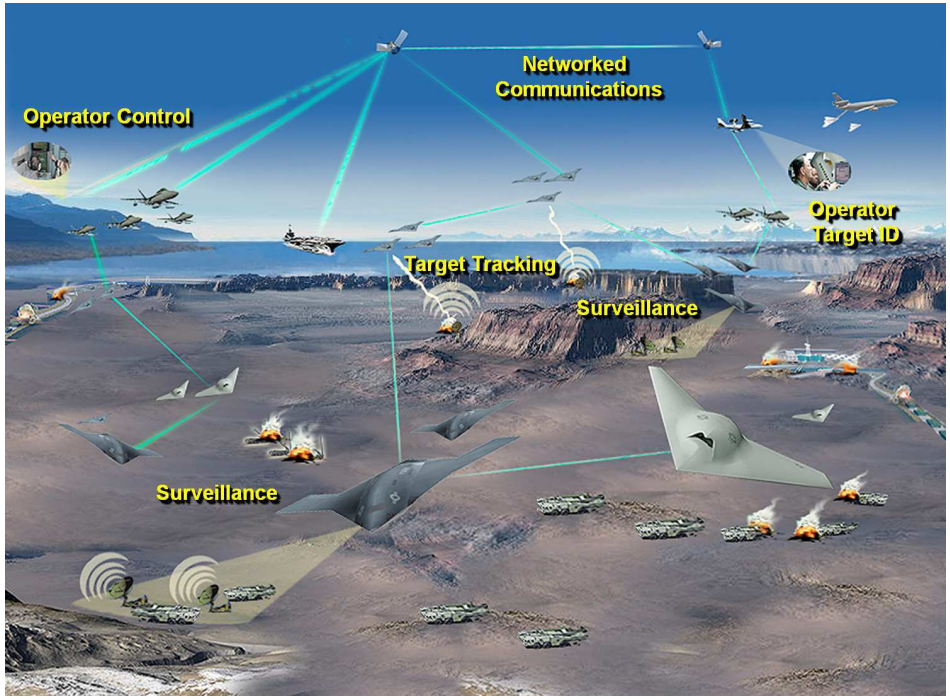
Motivation

Modern missions involve multi-agent teams cooperating to perform tasks:



- search and track;
- classify targets, monitor status;
- rescue operations.

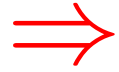
Key questions:

- How to coordinate team behavior to improve mission performance?
- How to hedge against uncertainty in dynamic environments?
- How to handle varying communication constraints?

Tasking approaches

Most involve centralized planning

- GCS plans and distributes tasks to all agents;
- Requires full situational awareness;
- High bandwidth, slow reaction to local changes



Motivates distributed planning

- Agents make plans individually and coordinate with each other;
- Faster reaction to local information;
- Increased agent autonomy

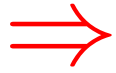
Key questions for distributed planning:

- What quantities should the agents agree upon? (Information / tasks and plans / objectives / constraints)
- How to ensure that planning is robust to inaccurate information and models?

Distributed Planning

Centralized Problem:

- Maximize mission score
- Satisfy constraints
- **Decision variables:**
  - Team assignments, Service times



Distributed Problem:

- Maximize mission score individually
- Satisfy constraints
- **Decision variables:**
  - Agent assignments, Service times

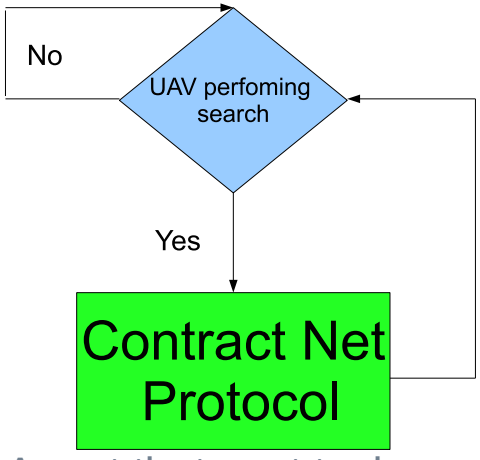
Main issues: Coupling and Communication:

- Agent score functions depend on other agents decisions
- Joint constraints between multiple agents
- Agent optimization is based on local information

Key challenge: How to design appropriate protocols?

- Specify what information to communicate
- Create rules to process received information and modify plans
- Performance guarantees
- Will algorithm converge to a feasible assignment?

Contract Net Protocol (CNP)



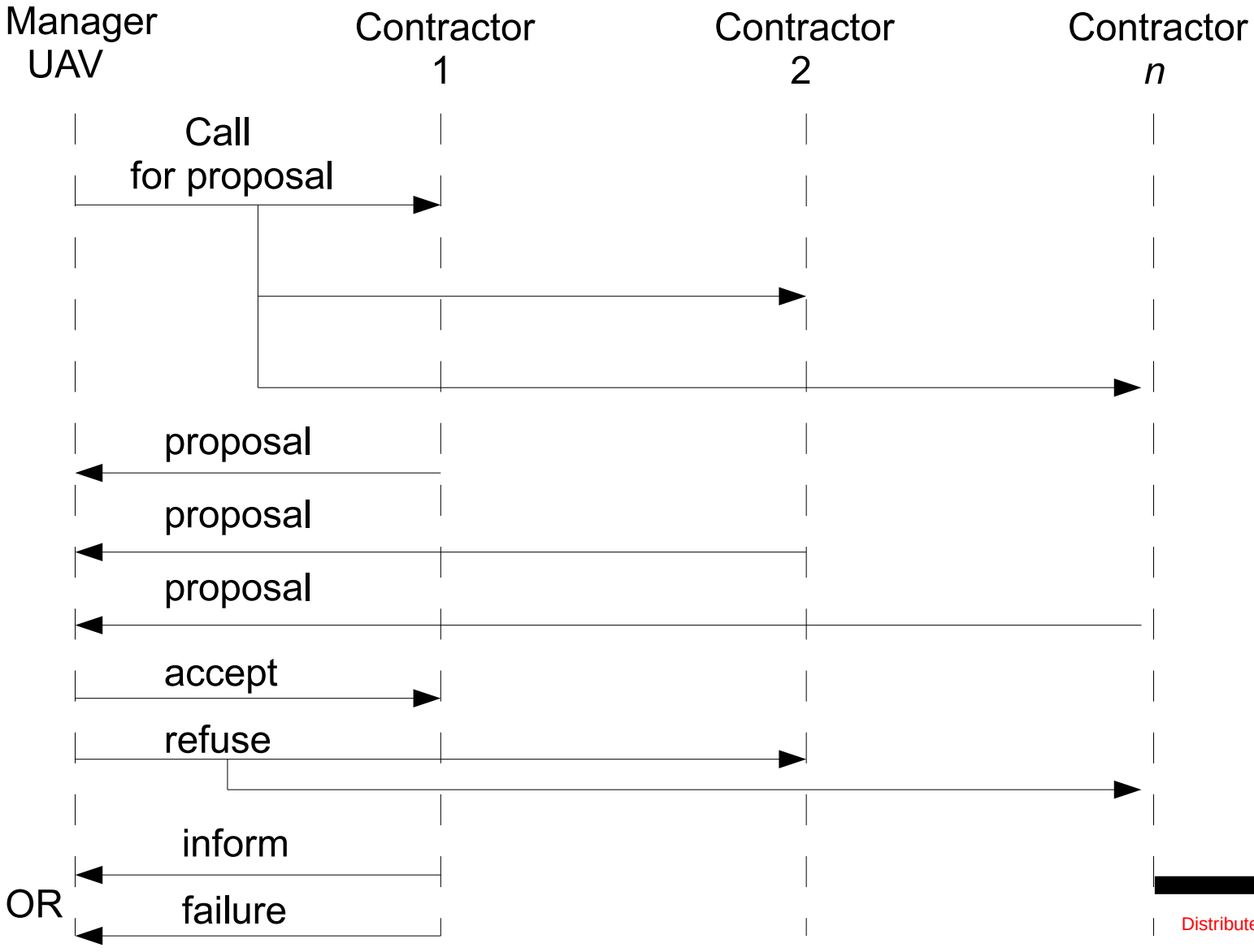
Application: An autonomous team of UAVs performing search and track missions

Agent that sent task announcement must choose between bids and decide who to "award the contract" to.

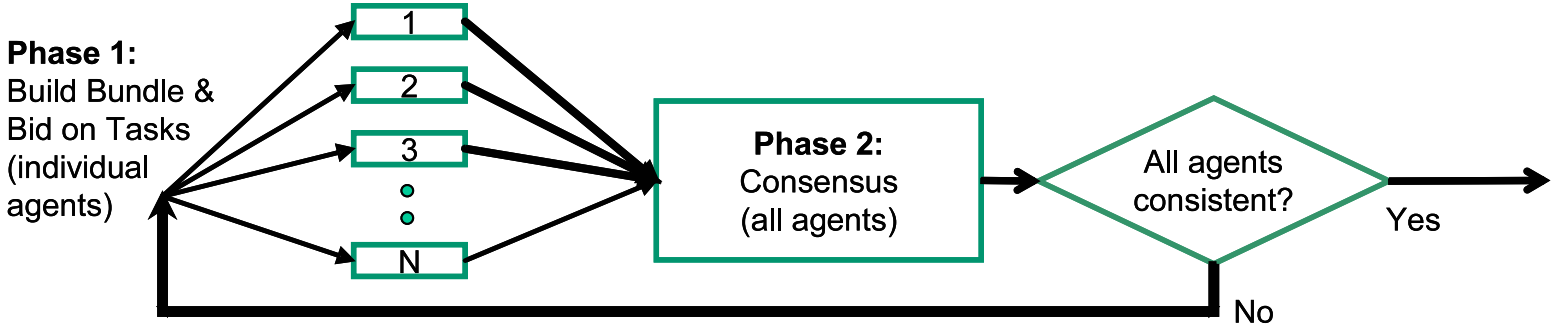
CNP stages:

- Recognition;
- Announcement ;
- Bidding;
- Awarding;
- Expediting.

Procedure Diagram



Consensus-Based Bundle Algorithm



Core features of CBBA:

- Task selection - Polynomial-time, provably good approximate solutions
- Guaranteed real-time convergence even with inconsistent environment knowledge
- Time-varying score functions (e.g. time-windows of validity for tasks)

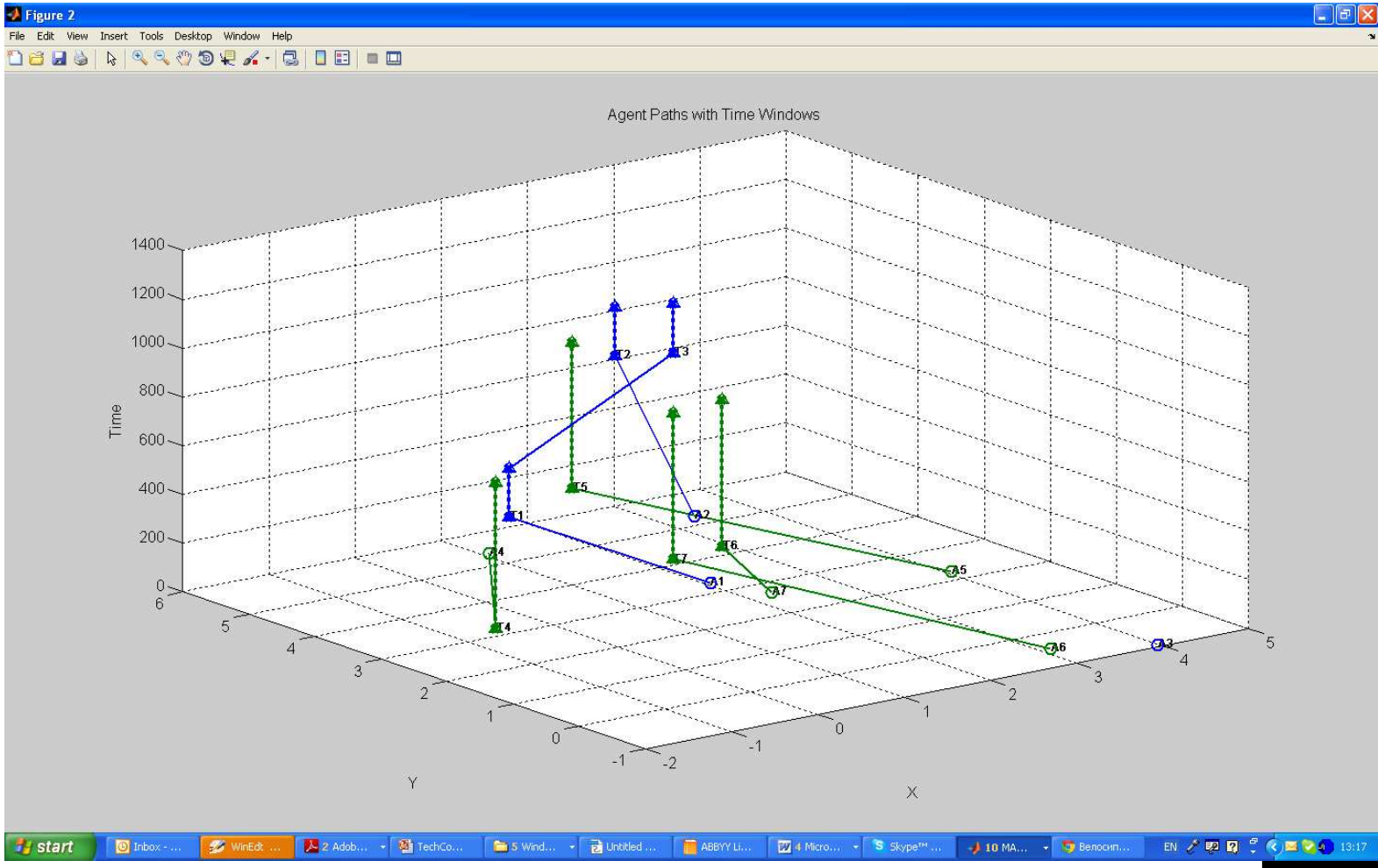
Application is the "Tethered UAVs Self-Assignment Problem":Find a logic that will enable the Tethered UAVs to self-deploy one UAV to each specified location.

Given:

- Locations (These are the locations pre-determined to be able to provide the necessary air-to-ground communications coverage for the ground users.)
- Homogenous UAVs

Simulation

Tasks with time windows of validity, heterogeneous agent-task compatibility requirements, and score functions that balance task reward and fuel costs.



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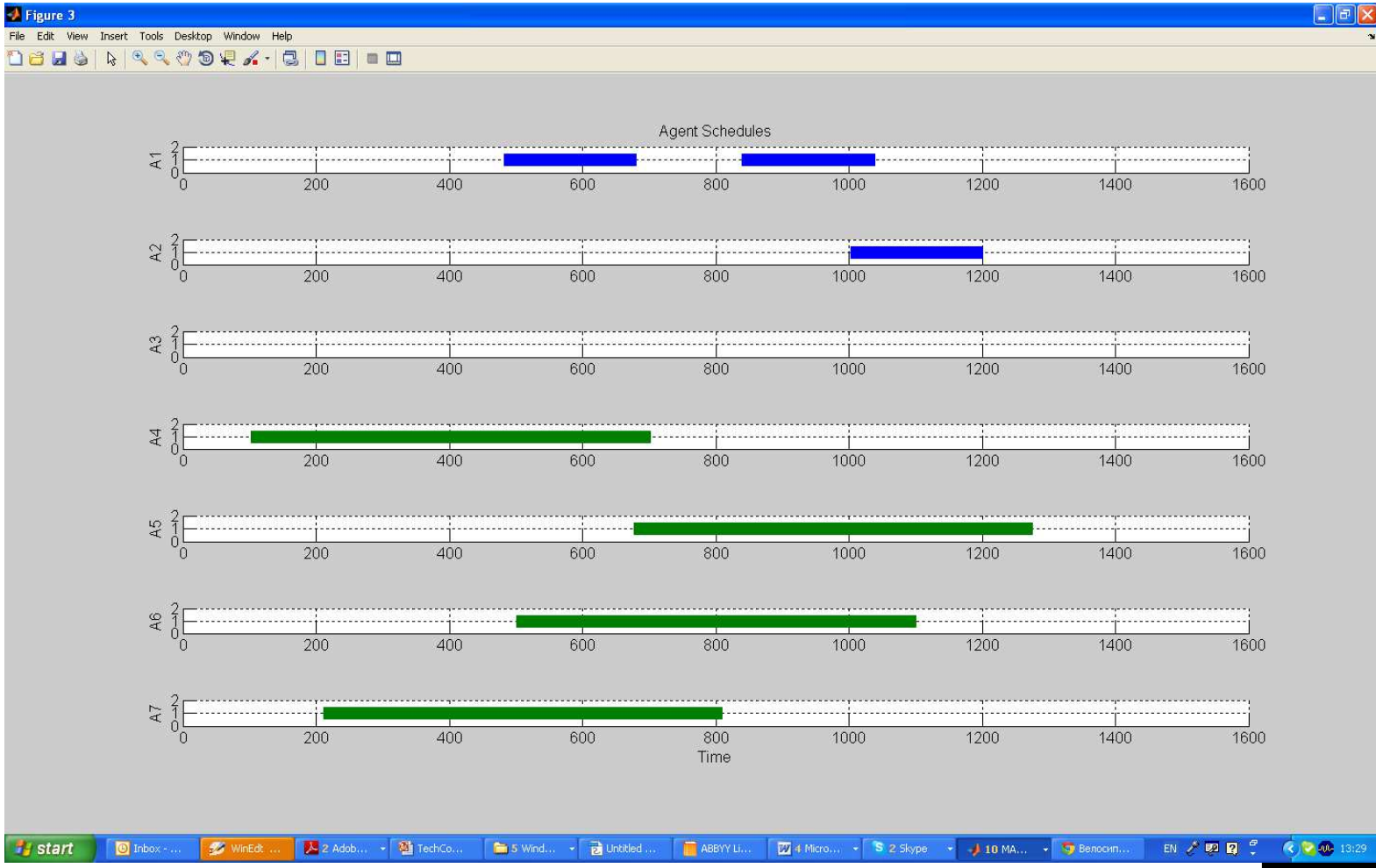
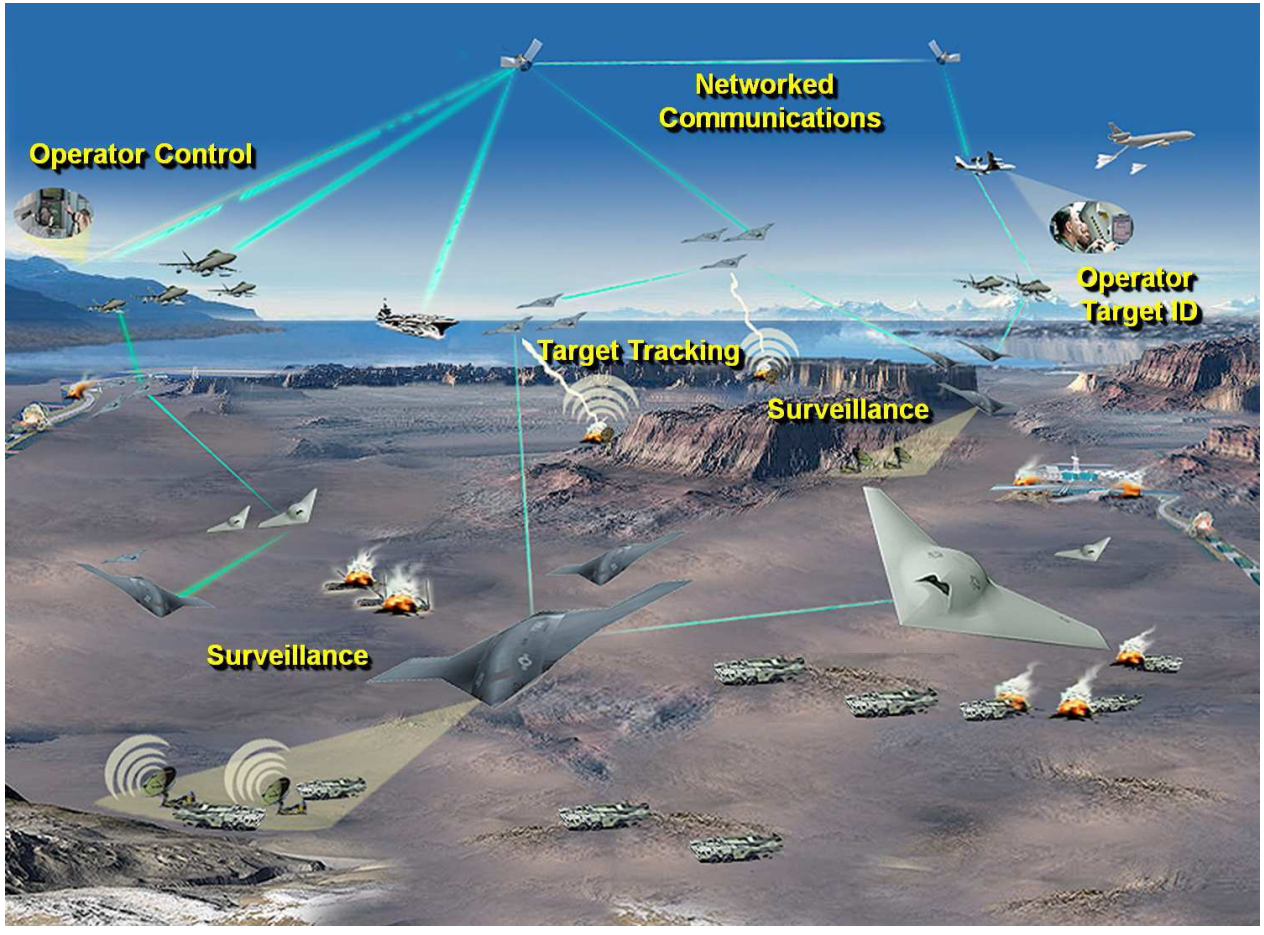


Summary



Distributed Tasking: We have shown that near optimal assignment can be found for complicated scenario where conventional method is not applicable.

The end

Thank you!