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Defence Science and
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A Dialectic for Network Centric Warfare

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1. Introduction

Network Centric Warfare

- *Network Centric Warfare (NCW) has been endorsed as an enabler for future warfighting for Australia.*
- *This is a consequence of bold pronouncements campaigning for a new era in the effective utilisation of military capability.*

"*Power to the edge (NCW - ed.) is a result of technological advances that will, in the coming decade, eliminate the constraint of bandwidth, free us from the need to know a lot in order to share a lot, unfetter us from the requirement to be synchronous in time and space, and remove the last remaining technical barriers to information sharing and collaboration*"

Mr John Stenbit (CIO - US DoD)

Network Centric Warfare

- *Currently, NCW remains a fledgling concept, leading some to question its merits.*
- *For example, Giffin and Reid (2003) assert*

> *"We believe that the NCW thesis is animated by a flawed theory of knowledge and knowledge development, with profound adverse consequences for the thesis as a whole".*

Dogmatism and Skepticism

- *Classic tension between dogmatism and skepticism.*
- *Dogmatism:*
  - *NCW proponents present NCW as an inevitable advancement*
- *Skepticism:*
  - *NCW opponents present NCW as a flawed religious excursion*

Which is correct?

- *Neither*
- *But both are necessary to advance*

Dialectical Method

- *The 19th century German philosopher George Hegel introduced the dialectical method for acquiring understanding.*
- *Stage 1: Thesis*
  - The dialectical method begins with a dogmatic thesis being embraced by a community.
- *Stage 2: Antithesis*
  - Skeptical concerns surface leading some to deny the thesis.
- *Stage 3: Synthesis*
  - A synthesis is formed that:
    - unifies the thesis and antithesis
    - avoids the myopic dispositions of each.

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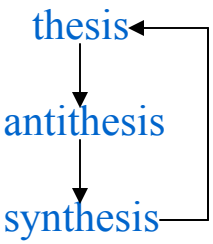
Dialectical Method



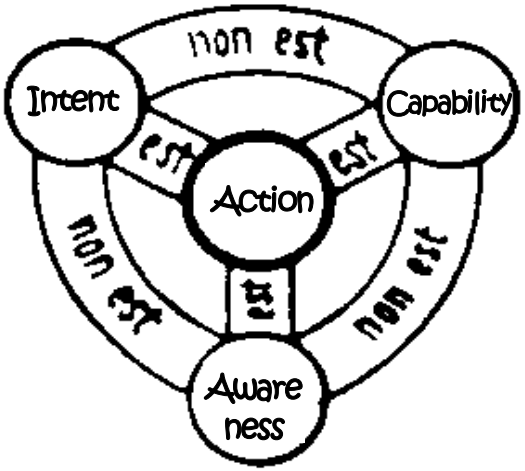
The synthesis may in turn become a thesis if the dialectical process is to continue.

- *Stage 1: Thesis* Network Centric Warfare (part 2)
  - The dialectical method begins with a dogmatic thesis being embraced by a community.
- *Stage 2: Antithesis* False Dreams (part 3)
  - Skeptical concerns surface leading some to deny the thesis.
- *Stage 3: Synthesis* Ubiquitous Command and Control (part 4)
  - A synthesis is formed that:
    - unifies the thesis and antithesis
    - avoids the myopic dispositions of each.

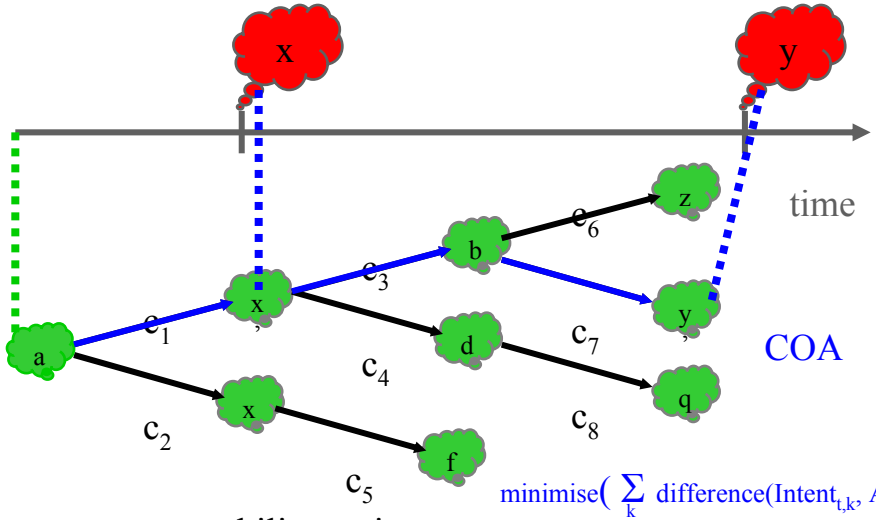
Talk will focus on the synthesis due to time constraints.

A Conceptualisation

- Aids in comprehending the significance of tenets
- We can understand (military) *action* as the utilisation of *capability* to achieve *intent*, given *awareness*.
- We view NCW as the *socialisation* of each of the above elements.



Intent, Capability and Awareness are in mutual tension



The choice of capability to achieve intent given awareness can be formulated as a dynamic programming problem

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4. A Synthesis: Ubiquitous Command and Control

(UC^2 – pronounced "you see too", pun intended)

"Unity with diversity"

based on work by Lambert (1999)

Some of the Issues Addressed by UC²

- How do we achieve *unity* in complex operations with the *diversity* of multi-agency, multi-national players and maintain *robustness*?
- *How* will C² actually work in a networked future? (e.g. self-synchronisation)
- Will military *hierarchies* be impacted? *How*?
- How can enterprises *respond* to continuous discontinuities?
- What is the role of *computing* in this future?
  - e.g. In 2000, US Congress ordered "a third of the ground vehicles and a third of deep-strike aircraft in the military must become robotic within a decade" ?

UC² has 9 tenets – we will briefly cover 8

Tenet 0: Adaptability (context)

1. Adaptation of **location**

- *Adaptations in transportation and telecommunications have altered the extent to which presence is influenced by distance*
- Increase in scope for both presence and virtual presence.

2. Adaptation of **function**

- *The adaptation of location is engendering an adaptation of the function performed by individuals, organisations and capabilities.*
- Scope for more contributors that can influence a function – increased cooperation and competition.

3. Adaptation of **structure**

- *The adaptation of function is inducing an adaptation of structure.*
- The effect of an increase in competition and strategic alliance is to erode the classical hierarchical structure to include networked structures.

Tenet 0: Adaptability

4. Adaptation of a**daptation**

- *The adapted networked structures* will increase the diversity available to an organisation, and this in turn, *will intensify the pace of change.*
- As the tempo of change increases, organisations must learn to adapt "Lego block" capability to satisfy intent given awareness
- Organisations have traditionally understood themselves as persistent, and as a consequence, changes in organisational location, function and structure have often been violent.
  - A process view of organisations, such as Senge's (1990) "learning organisations", counters this violence
- Organisational change becomes less a centralised decision and more of an environmental effect of adaptations in location, function and structure.

Tenet 1: Decision Devolution

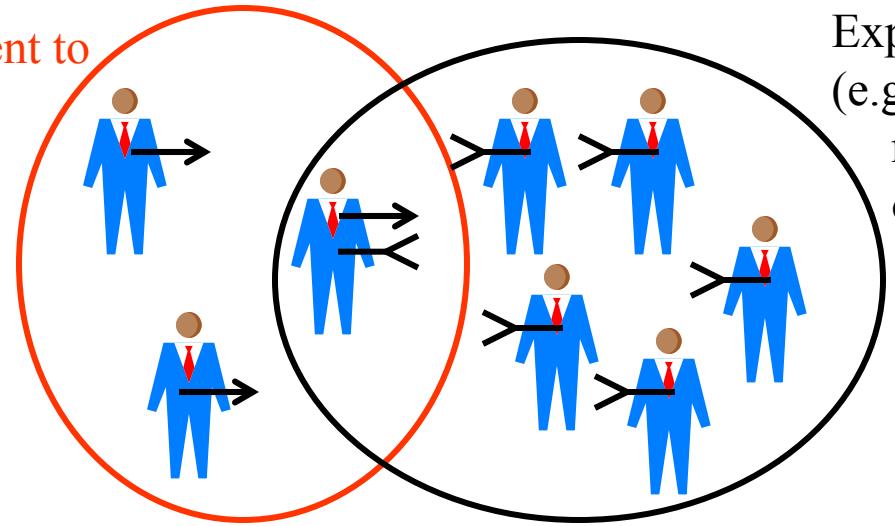
"UC^2 systems represent a devolution of decision making power from C^2 centres to platforms which are designed to provide alternative functionality. Under this proposal, command and control becomes an additional function performed on the likes of frigates, fighters, unmanned vehicles, and missiles. This signals a significant shift in emphasis toward the tactical level, and in particular, to the warfighters. C^2 centres, as we now know them, may continue to exist, but their utility will diminish". Lambert(1999).

- This aligns with the "power to the edge" sentiments expressed by NCW proponents.
- Founded upon the idea that additional individuals or entities are not always required to govern collectives. When appropriately equipped, collectives can sometimes govern themselves. e.g. eBay.
- Dynamic liaisons adaptively form from operational assets without the oversight of a command headquarters.
- *Benefit: flexibility (e.g. through sharing load) and redundancy*

Tenet 1: Decision Devolution

Command
Expression of intent to another

eBay: Vendor expresses the intent of sale



Control
Expression of a capability (e.g. a plan) to another & monitoring and correction of the execution of the plan

eBay: the process by which the Purchaser acquires the sale item

eBay: No ruling class!
Control works through self-monitoring and self-correction against fraud.
Protocol is "over the wire".

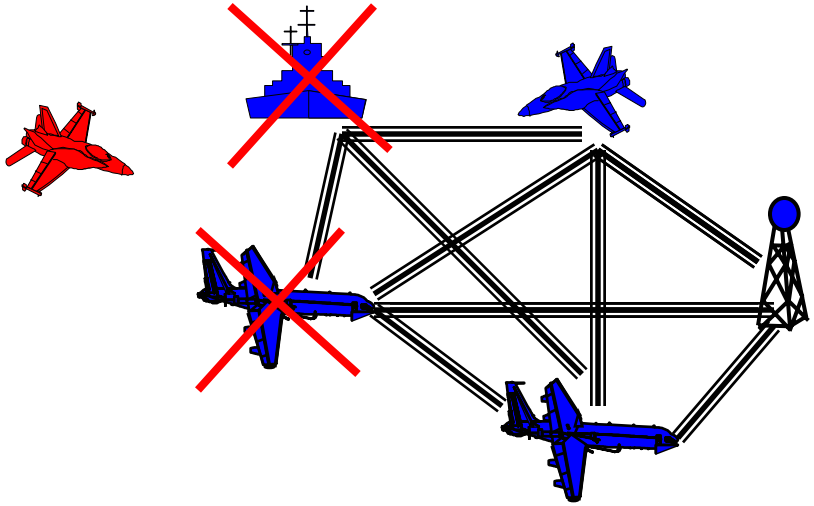
Tenet 2: Ubiquity

> "Ubiquitous C^2 systems are so named because they advocate a C^2 capability on *every* platform. Indeed, individual platforms will generally have several autonomous C^2 components. The term "similar" is chosen to reflect a requirement for inter-operability, so that each platform based C^2 component can effectively communicate with the others in the UC^2 system. It equally acknowledges scope for differences, both in terms of the underlying C^2 architectures resident on platforms, and in terms of the knowledge and opinions held by those C^2 components ". Lambert(1999).

- Argues for a C^2 component on every platform.
- In doing so, it argues for similar, not identical components.
- Highlights two issues:
  - Graceful Degradation
  - Agreement (to be described later)

Graceful Degradation

- Having a C^2 capability on <u>every</u> platform allows C^2 for the system as a whole to degrade gracefully under strike by reconfiguring C^2 among the remaining assets.



- In principle, defeating a UC^2 system amounts to defeating <u>all</u> of its assets.
- *Benefit: robustness*.

Tenet 3: Automation

> "Automation is the primary mechanism for acquiring a similar C^2 capability on every platform. Some decision making can be fully automated. Other aspects will perform better with human interaction, with the choice between the two being mediated empirically. This promotes the role of automated decision makers and automated decision aids within UC^2 systems, with a similarity in C^2 components emanating from a similarity in the automated decision makers and aids. The automated decision aids will vary in their reliance on human cognition, ranging from elementary structured interfaces through to complex decision advisory systems". Lambert(1999).

- Argues that some expertise should be automated through software.
- Automated software expertise facilitates both automated decision makers and automated decision aids.
- The advantage of automated software expertise is that it is easily replicated, adapted and distributed.
- *Benefit: automated software expertise enables the ubiquity of C^2 capability by making expertise more readily transferable.*

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Tenet 3: Automation

"The Matrix" – Warner Brothers

- This expresses the idea, except we would download expertise relevant to both the person and the helicopter, *to the helicopter*, not the person!
- Two aspects to automated expertise:
  - Semantic machines
  - Cognitive machines

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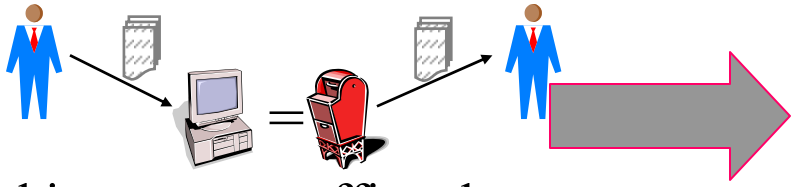
Semantic Machines

Mind set change



machines as post offices boxes

- *machines understand the meanings of the information they store*
- *machines represent propositional content*

e.g. "Saddam Hussein bought munitions from Mussoria"
- *syntactically can retrieve from a Saddam search*
- *semantically can also retrieve from an Iraq search*

Primitive symbols capable of describing military interaction (Lambert, 2003).

Social:	group, ally, enemy, neutral, own, possess, invite, offer, accept, authorise, allow, …
Intentional:	individual, routine, learnt, achieve, perform, succeed, fail, intend, desire, belief, expect, anticipate, sense, inform, effect, approve, disapprove, prefer, …
Functional:	sense, move, strike, attach, inform, operational, disrupt, neutralise, destroy, ...
Physical:	land, sea, air, outer_space, incline, decline, number, temperature, weight, energy, …
Metaphysical:	exist, fragment, identity, time, before, space, connect, distance, area, volume, angle, …

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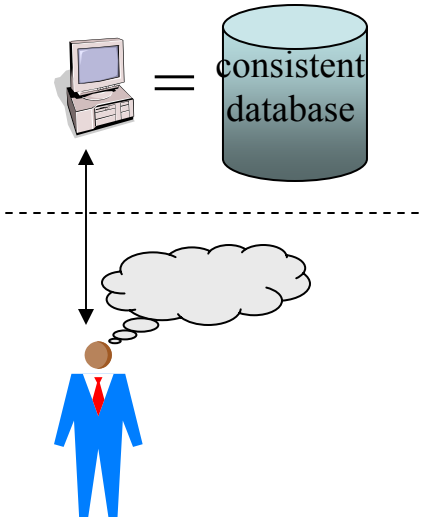
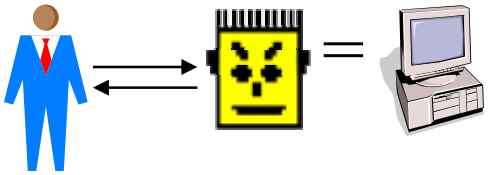
Cognitive Machines



machines have data that people reason about

Mind set change

machines have agents that reason with people



ATTITUDE originally developed by DSTO to intelligently control the Swedish AEW radar.

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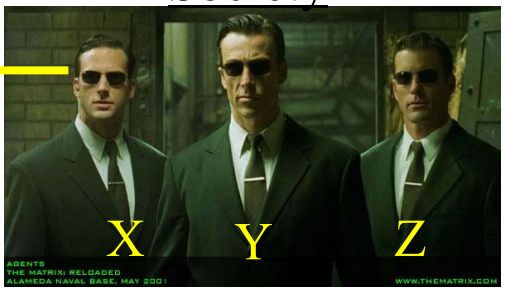
Cognitive Machines

Society



ATTITUDE Cognitive Model

(Lambert, 2003a)

X believes that ξ in event E with priority r and prob p
X believes that ξ if ζ_1 and ... and ζ_j in event E with priority r and prob p
inferring α in event E with deduction d with options λ
Beliefs$_{X,t}$

X expects that α by t
Expectations$_{X,t}$

X anticipates that α with β
Anticipations$_{X,t}$

Awareness$_{X,t}$

X intends that α with subgoals G and priority r
Intentions$_{X,t}$

X desires that σ from routine element q with context f for superior goal g with intention i and with subgoals G, while associated with task t and expiry e
Desires$_{X,t}$

Volition$_{X,t}$

X senses that α with priority r through sensor s
Sensations$_{X,t}$

X effects that α with priority r through effector e
Effects$_{X,t}$

X informs Y that Ψ α with priority r
Communications$_{X,t}$

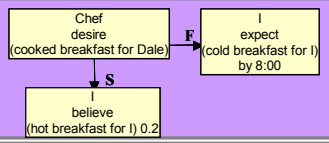
Interaction$_{X,t}$

X expires action ω by time t
Expirations$_{X,t}$

X tasks that action ω for Y has priority r
Tasks$_{X,t}$

Action$_{X,t}$

WM$_{X,t}$



LTM$_{X,t}$

Memory$_{X,t}$

•selects
•performs
•redirects

Control$_{X,t}$

X_t

Tenet 4: Integration

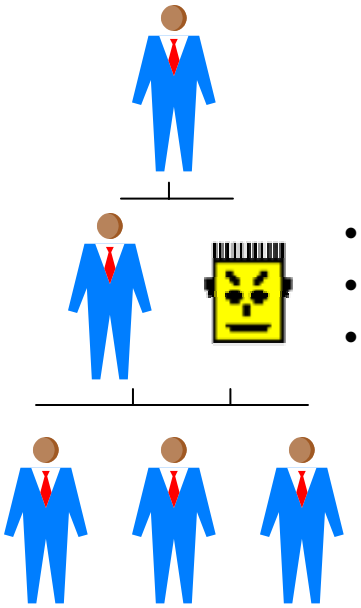
> "In UC^2 systems, the automated and human decision making is fully integrated, with each assessed equally on it merits. This includes the currently controversial option of allowing the machine to at times override the human. The introduction of automated rules of engagement components (essentially legal expert systems) within weapons and weapon systems illustrate the point. The resulting "moral weapons" will have the ability to assess and decline targeting requests when rules of engagement violations are deduced. Decisions to override these moral weapons can be logged for subsequent review ". Lambert(1999).

- Integration exists to complement the weaknesses in some parts of a UC^2 system with strengths in other parts of a UC^2 system.
  - This includes the division of labour between people and machines.
- There are two considerations for the integration of people and machines
  - Mixed initiative
  - Improved interaction
- *Benefit: more effective combination of people and machines*

Mixed Initiative

- Option of allowing the machine to at times override the human

- For automated agents: *competency* then *responsibility* then *authority*



- competency
- responsibility
- authority

1. *Competency* will depend on the *expertise* embedded within it.
2. *Responsibility* will follow from the *social agreements* it forms, given available competencies.
3. *Authority* is not determined by a priori rank, but depends upon the *role it assumes in social agreements*, given available competencies.

Tenet 5: Distributed and Decentralised

> "UC^2 systems primarily endorse a distributed and decentralised management structure. Each decision maker has the capacity to ask (pull knowledge), tell (push knowledge), command (push tasks) and obey (accept tasks). This potentially secures a flatter, more efficient, network structure, liberating us from a hierarchical C^2 framework whenever we choose to do so. It also introduces a command fusion problem to complement the existing information fusion problem, as each decision maker is now forced to attend to, and possibly fuse, requests for its resources from multiple sources". Lambert(1999).

- The fifth tenet argues that C^2 should be distributed across location and support a decentralisation of intent.
- *Benefit of distribution: robustness - distribution across location affords protection from spatio-temporally constrained strike capabilities e.g. missiles.*
- *Benefit of decentralisation: robustness - decentralisation of intent affords protection from strike capabilities that target centralised will (origin and ownership of intent) e.g. assassination, blackmail.*

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Australian NCW Tenets

"Human Condition" unique to AS NCW

1. Professional mastery is essential to NCW.
2. ***Mission command*** will remain an effective command philosophy into the future.

Almost identical to first three US NCW tenets

3. Information and intelligence will be shared if a network is built by connecting engagement systems, sensor systems and command and control systems.
4. Robust networks will allow the ADF, and supporting agencies to collaborate more effectively and achieve shared situational awareness.
5. Shared situational awareness will enable self-synchronisation, which helps warfighters to adapt to changing circumstances and allows them to apply multidimensional manoeuvre.

(Directorate of Future Warfighting, 2004:pp.2-2)

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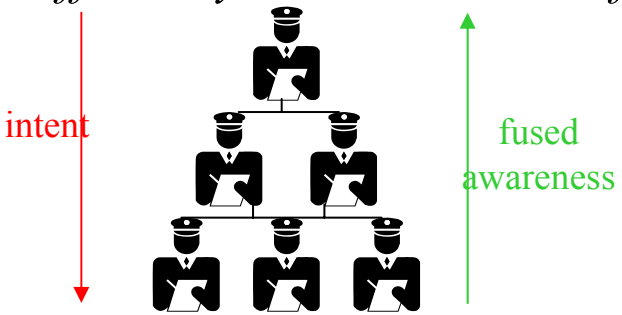
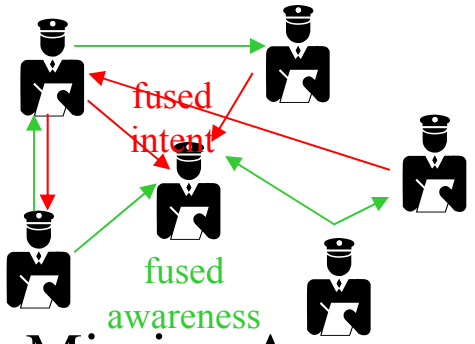
Tenet 5: Distributed and Decentralised

- Decentralisation of intent allows for agreements about intent as well as awareness.
- "Mission agreement" supersedes "mission command"
  - mission command (chains of pair-wise agreements between commander and subordinate) is but one type of mission agreement
  - can also have mission agreements that are not restricted to a top down cascading of intent
  - e.g. intent can be introduced at "the edge" of an organisation and propagate inwards if it garners sufficient support
  - this introduces a "command fusion" issue to complement the "information fusion" issue we already have under mission command

– *Benefit: efficiency in achievement of intent.*



Mission Command



Mission Agreement

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Mission Agreement Example

(from “13 Days” Beacon Pictures)

Tenet 6: Social Coordination

"In general, each decision maker is concurrently confronted with ask, tell, command and obey request options. In a UC^2 system, selection between these is determined by attempting to obtain the best possible outcome for the UC^2 system in the time available. There are a number of potentially controversial elements to this standpoint: *(including)*
• activity is decided by system utility, which need not correspond to command authority - competitive advantage can override military rank; ". Lambert(1999).

- How do we manage this level of flexibility without anarchy?
- We achieve a decision making capability by instituting social agreement protocols that coordinate agent (human and machine) societies.
- The institutionalisation can be "over the wire" through software, i.e. more sophisticated variants of workflow systems.
- Agreements require a legal basis for the application of force and tracing of consequences. (e.g. what happens to Commander Eckert? – 13 Days)

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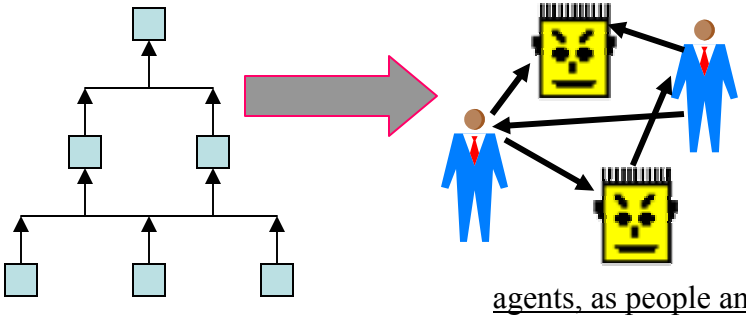
Legal Agreement Protocol (LAP)

- LAP delivers full contract law between agents.
- LAP may be supported by a publish-subscribe infrastructure.

Agreement protocols supersede simpler hierarchies with a network centric agreement capability.



agents, as people and machines, collaboratively and competitively interact to achieve intent

SPEECH ACT	SEND	RECEIVE
Request for Proposal (requests X α)	Contractor X uses domain knowledge to determine potential proposers $\{Y_1, \ldots, Y_n\}$ for RFP (request for proposal) goal α and sends X requests that α to each Y_i. A request can be sent at anytime.	Potential proposer Y_i receives X's requests for α. In response, Y_i determines its best proposal β_i, and if Y_i can undertake the proposal β_i, then Y_i sends a propose speech act.
Retraction of Request (retracts X α)	Contractor X decides not to proceed with a sent RFP for a and sends this to the individuals $\{Y_1, \ldots, Y_n\}$ that the RFP goal α was initially send to. A retraction of an RFP can occur, without penalty, any time before acceptance of an offer contributing to the RFP.	Potential proposer Y_i receives a retraction for RFP goal α and deletes all proposals and offers associated with it. Damages can be sought by Y_i against X for each of Y_i's offers accepted by X.
Proposal (proposes Y_i β_i X α)	Proposer Y_i sends a proposal for β_i to X to achieve α in response to a request from X. The proposal can be sent any time before the request is retracted or a contracts for a has been let.	Contractor X receives a proposal bi to achieve a from Yi. In response, X determines whether bi is a better proposal for a than any currently received. If it is, then X sends an invitation for Y_i to offer β_i formally.
Withdrawal of Proposal (withdraw Y_i β_i X α)	Proposer Y_i sends a withdrawal to X for proposal β_i to achieve α. Y_i will do this if it becomes clear that Y_i cannot perform the proposal. A withdrawal for β_i can be sent any time before an offer for β_i is sent.	Contractor X receives a withdrawal of proposal β_i from Y_i. X removes proposal β_i and all of its dependencies.
Invitation to Offer (invites X Y_i β_i α)	Contractor X sends an invitation to proposer Y_i to formally offer proposal β_i for request α. X can send such an invitation whenever X believes Y_i's proposal β_i is the best proposal for α.	Proposer Y_i receives an invitation from X for proposal β_i to achieve α. In response, Y_i can send an offer θ_i to X for β_i, but this will be contractually binding on Y_i if X accepts that offer before Y_i revokes it.
Decline of Invitation (decline Y_i β_i X α)	Proposer Y_i sends to X a decline to offer for proposal β_i to achieve α. Y_i can do this at any time.	Contractor X receives from Y_i a decline to offer for proposal β_i to achieve α. In response, X must delete β_i and all dependent states.
Offer (offers Y_i θ_i β_i X α)	Proposer Y_i sends an offer θ_i to X for proposal β_i to achieve α. Y_i will do this if Y_i believes it is prepared to be obligated, as θ_i will be contractually binding on Y_i if X accepts that offer before Y_i revokes it.	Contractor X receives an offer θ_i for proposal β_i to achieve α. If X accepts the offer then X is contractually obligated to it. X can instead delay acceptance, but risks Y_i revoking the offer before X can accept it.
Revocation of Offer (revokes Y_i θ_i β_i X α)	Proposer Y_i sends a revocation of offer θ_i to X for proposal β_i to achieve α. Y_i will do this if Y_i believes it has a better alternative. This succeeds provided X has not already accepted the offer, in which case Y_i will be liable for damages. The revocation of the offer occurs at the time at which it is sent, not received.	Contractor X receives a revocation of offer θ_i from Y_i for proposal β_i to achieve α. In response, X must delete θ_i and all dependent states and is not entitled to damages unless θ_i has been accepted.
Acceptance of Offer (accepts X Y_i θ_i β_i α)	Contractor X sends acceptance of offer θ_i from Y_i for proposal β_i to achieve α. The effect is that both X and Yi are contractually obligated to achieve θ_i. If either party renigs, then they are liable for damages under breach of contract.	Proposer Y_i receives an acceptance of offer θ_i for proposal β_i to achieve α. At this point Y_i becomes aware of the mutual obligation.
Rejection of Offer (rejects X Y_i θ_i β_i α)	Contractor X sends a rejection of offer θ_i from Y_i for proposal β_i to achieve α. The effect is that no contractual obligation exists between X and Y_i. X will do this if X believe it has a better offer or potential offer.	Proposer Y_i receives a rejection of offer θ_i for proposal β_i to achieve α. At this point Y_i deletes offer θ_i and proposal β_i and all of their dependencies.

Tenet 7: Management Levels

Each UC^2 system is understood and managed at four levels.

- the Individual Level, which is concerned with each individual decision maker, automated or otherwise, in the UC^2 system;
- the Platform Level, which is concerned with the collection of individuals resident on a single asset platform;
- the Team Level, which is concerned with a system of assets dedicated toward achieving the same mission within the UC^2 system; and
- the Sociological Level, which is concerned with the multi-mission interaction between systems of system assets. (Lambert, 1999a:pp.36)

- Levels characterised by diminishing proximity and increasingly flexible options for social coordination.
- Identifies natural and social constraints that will necessarily be imposed on what might otherwise be the *laissez-faire* management style of tenet 6.

5. Conclusion

NCW is Refined by UC^2

NCW Tenets

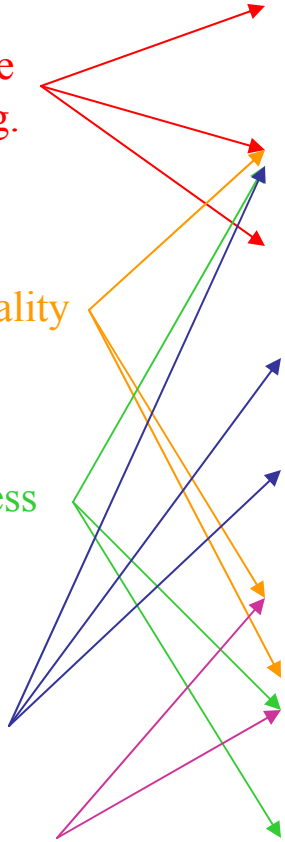
1. A robustly networked force improves information sharing. (US)

2. Information sharing and collaboration enhance the quality of information and shared situational awareness. (US)

3. Shared situational awareness enables self-synchronization. (US)

4. Professional mastery is essential to NCW. (AS)

5. Mission Command will remain an effective command philosophy into the future. (AS)



UC^2 Tenets

0: **Adaptations** in transport and telecommunications are adapting the influence distance has on presence, which is adapting organisational function toward strategic alliances, which is adapting organisational structure toward networks, which is adapting both the impact on localised events and the pace of change.

1: **Decision Devolution** enables the social collective to decide, rather than governing individuals, in order to benefit from the diversity of expertise.

2: **Ubiquity** of C2 offers extreme robustness through agreements between similar, rather than identical, C2 capabilities on every platform.

3: **Automation** provides the basis for ubiquity by extending intrinsic human capabilities with automated semantic and cognitive decision makers and aids.

4: **Integration** between people and machines is managed through mixed initiative strategies and by equipping cognitive machines with storytelling technologies.

5: **Distributed** locations allow seamless virtual integration with the robustness of physical diversity **and Decentralised** intent provides unity through mission agreements with robustness through a diversity of underlying intent.

6: **Social Coordination** among people and machines in a collective can be flexibly achieved through automated social agreement protocols and social policies.

7: **Management levels** naturally arise from commonalities of location and intent.

UC^2 is Command and Control with 2020 Vision

- As a purely academic exercise to free yourself from legacy thinking...

  Pretend that we are designing a system for offensive terrorist units and defensive counter-terrorist units,

  a contest for which we have no established capability and so no preconceived approach.

- Then ask yourself which system you would adopt – the conventional military approach or UC^2?

Robert McNamara from “The Fog of War” – Sony Pictures