
# *Intelligent Aided Communication (iaC) in a Command and Control Environment*

***Findings from and concepts developed under Phase I of DARPA SBIR SB041-020***

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# *Modern Command and Control …*


*Requires* communication, collaboration, and coordination among US (and Coalition) forces
- Command Centers serve as “hubs” (or bottlenecks) in a vast network

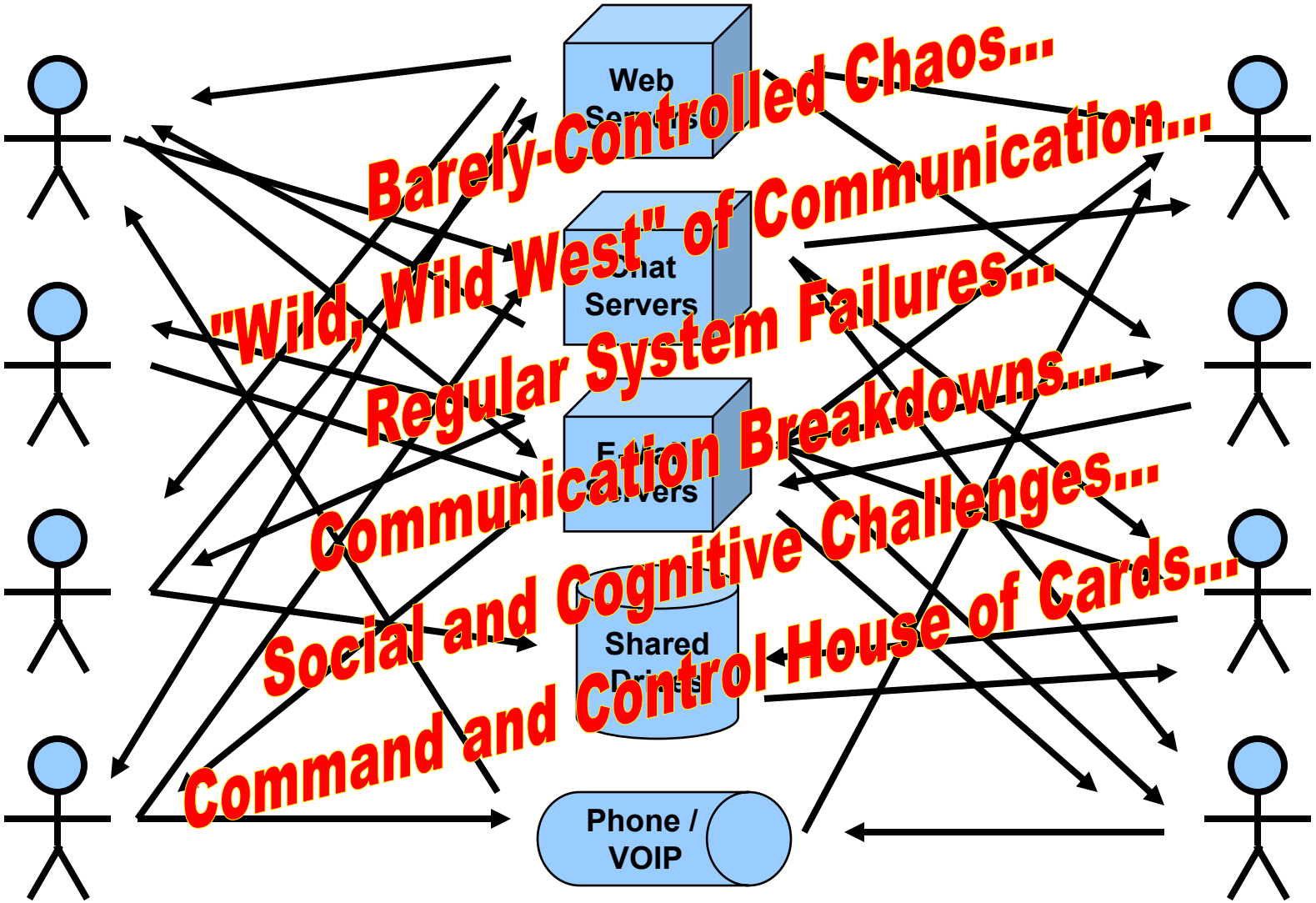
Is synchronous *and* asynchronous; tactical *and* strategic in nature

Involves participants who are often co-located *and* distributed
- Geographically / Organizationally / Functionally
- Focus / purpose / schedule / resources

Suffers from numerous, complex, related issues
- Human cognitive abilities / limitations
- Technologies / Infrastructure
- Policy / Process / Business Rules / Doctrine
- Cultural effects (organizational, national, etc.)

Can benefit *greatly* from:
- Shared Mental models and goals / shared understanding of context
- Shared Situation Awareness
- Transactive Memory *and* Communities of Interest

# Today's Communications Systems



# *Just a few representative operational issues / problems …*


- High-stakes, time-compressed, technology- and infrastructure-deprived information exchange and decision making environments
  - Decision-making often based on ambiguous or conflicting information
- Stove-piped communication, collaboration, situation awareness, and decision support tools = inefficient info exchange, sub-optimal SA
  - Difficulty identifying related, similar, or redundant exchanges
  - Difficult to remain aware of current or emerging "channels" and shifting or splitting of locus of communication / collaboration
  - Difficult / impossible to explicitly relate spatially- and non-spatially relevant information
- Related and overlapping information "spaces"
  - Geospatial, temporal, contextual, organizational, etc.
- Separate methods of communication / collaboration
  - Verbal, textual, visual, etc.

# R&D Successes and Failures

## Successes / Breakthroughs in our understanding of:

- Human information "processing" & decision-making
- SA, and individual and team performance
- COA generation and selection
- Visual perception and information representation
- Technologies and Processes:
  - Infrastructure
  - Data & Info Management
  - Decision Support Systems / Decision Aids
  - Training
  - Systems control (sensors, weapons, etc.)

## Failures / Missing Pieces:

- *Too much information* / Lack of *cognitively-based* information management
  - Filtering
  - Organizing
  - Simplifying
  - Info and task "Load Balancing"
  - Context
  - Presentation
- Too narrow a focus on *conscious* thought processes
  - Humans aren't machines
  - We often decide / act without conscious thought – how?
  - Symbiotic relationship between Man and Machine not recognized / addressed
- Too narrow a focus on individuals / small teams rather than larger groups

# Information Flow Today (1 of 2)

Much of observed information flow focused on "raw" or "semi-processed" information

- Need to emphasize filtering, processing, interpreting, and presentation of info
- Focus should be on problems / issues / and proposed solutions

Information flow generally falls along two lines:

- Structured / Required / Official (Static, Predictable Flow)
  - » Often based on tradition, policy, and/or organizational hierarchy
  - » Perhaps best served by "push" technologies on a low-priority, not-to-interfere basis
- Unstructured / Transactive Memory (Dynamic, Changing Flow)
  - » Often based on mission / task / operational requirements
  - » Perhaps best served by "pull" and "peer-to-peer" technologies and would have higher-priority

Information flow characteristics

- Some information flow is event-driven, some is event-independent
- Limited evidence of prioritization of information flow
  - » Stove-piped communications systems exacerbate this – information with varying priority levels flow in simultaneously; it is up to the user to decide what to deal with first…
- Confusion regarding expected info products occasionally exists
  - » Expectations regarding content, periodicity, triggers, etc.
  - » Sometimes confusion is recognized, sometimes it reveals itself over time
  - » Confusion and expectations often must be worked out / developed iteratively

# *Information Flow Today (2 of 2)*


- Regularly observed method of sharing context is to taking screen captures of COP (moments in time), and emailing or otherwise sharing picture
  - These are sometimes augmented by markups or accompanying text
  - Similar to work being done on other projects…
- Most information flow is human-initiated; need tool that recognizes requirement to communicate, then automatically takes action or recommends communications (i.e., participants, content, periodicity, and any required follow up comms)
- Much information flow seems to be based on a “push assumed” or “receipt assumed” model

# Coalition Operations Issues for Further Consideration

Share-ability / Releasability issues impact / influence operations

- Briefings
- Consideration of tasking, orders, etc.
- Information flow in OPCON
- Required sanitization measures impact enclave operations

Share-ability / Releasability issues impact information flow; issues include:

- Who to send info to is always an open question
- Where to get needed info (what is actually available, where to look for it, how to access it, how to interpret / use it, etc.)
- Lots of very vital info flows via chat – not all coalition participants have chat or use compatible systems
- Determining what can / should be shared can be difficult – fear of error is significant
- Determining / verifying that sent info has been received can be difficult

# *Overall Project Goals for SBIR "Knowledge Flow in Command & Control"* *(Phases I-III)*


- Design and develop "intelligent," "aware" command center concepts and technologies based on the symbiotic relationship between human users and their technologies
  - Combine / leverage / adapt existing theories, models, technologies, infrastructure, and tools as appropriate – develop totally new theories, technologies only as necessary
  - Take advantage of / leverage the strengths of humans and machines – engineer the weaknesses out of the system
- Validate and commercialize the necessary theories, concept, technologies, and infrastructure to improve information / knowledge flow in modern C2

# *Some Relevant Theories / Concepts …*

## Social Interaction Theory

- Asserts communication as a system in which the actions of single participants cannot be considered themselves, only as a part of the whole (Watzlawick)

## Social Exchange Theory

- Allows for the social exchanges between individuals involved in the larger groups to be analyzed
- Allows for researchers to ask the question of “why” people are involved in an exchange instead of “what kind” of exchange they are involved in
- Allows for macro-structures to be analyzed
  - » Structure of relations is conceptualized in terms of social networks with emphasis on the form of social relations among positions, within the larger group

# *More Relevant Theories / Concepts …*

## Complexity Theory

- States critically interacting components self-organize to form potentially evolving structures exhibiting a hierarchy of emergent system properties (Bhaskar)

## Theory of emergent organizations

- Asserts bottom-up organizations of complex systems exhibit seemingly intelligent behavior far greater than what may be expected of their multitudes of individual, simple units (Schweitzer)

## Information Theory

- Regards information as symbols that carry information between people. All communication involves three steps – coding a message at its source, transmitting the message through a communication channel, and decoding the message at its destination (Shannon)

# *A better way… Intelligent Aided Communication (iaC)*

A scientifically based, practical approach to facilitating improved communication and optimizing data, information, and knowledge flow in US Command and Control

# *iaC Concept Overview*


## We have met the enemy – and they are us…

- Humans evolved over eons in small, generally hierarchically organized groups – we've never adapted our communication to large, distributed social / communication networks
- "Language" is a limiting factor; conveying SA, knowledge, context, and understanding to another person is *very difficult*
- Our modern technology gets in the way of communicating *effectively* – and makes it too easy to communicate *efficiently*

## We have the technology… better, stronger, faster…

- Existing and emerging technologies can help solve these problems – but only if we use them correctly
  - » Improved interfaces and visualizations
  - » Database technology
  - » Agent technology

} iaC building blocks

## iaC helps humans focus on *communicating* by taking over the mundane

- Transparently manages the *who, what, when, where,* and *how* of data transfer – lets human concentrate on important tasks

# *iaC Technology Overview*


**People are continuously identified to the system**

- Identified by wearable “smart ID tags”; updates are sent as needed (e.g., changes in location / job / technology / communication path)

**Personal Agents* manage behind the scenes based on evolving user profiles**

- Communication flow between people / systems
- Information presentation / visualization

**User Profiles contain relevant information about communicators**

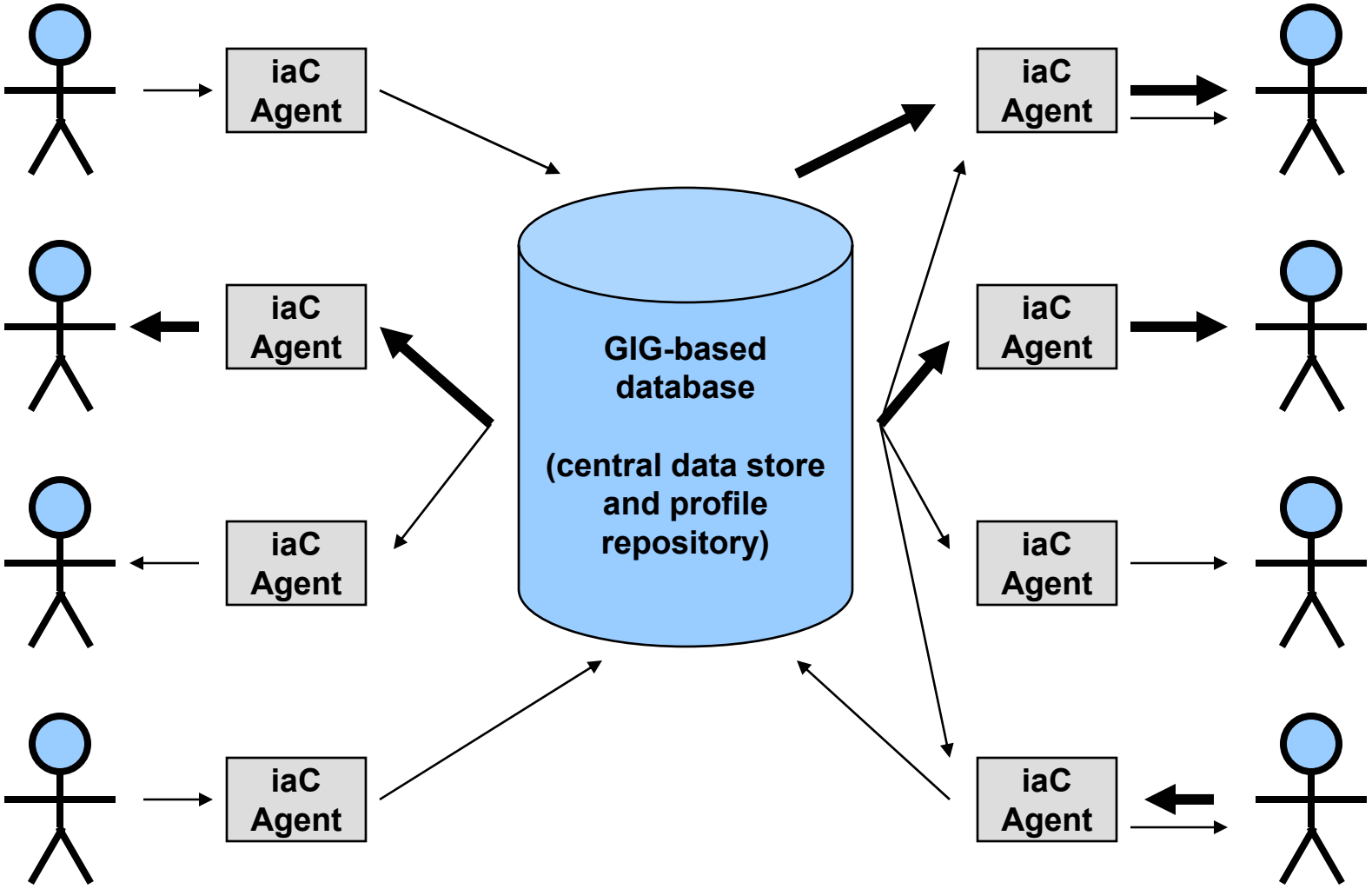
- Knowledge, skills, abilities, training, experiences, etc.
- Current tasks / job roles / responsibilities / information requirements
- Available technologies / communication paths
- Personal preferences
- Observed behaviors

**iaC Agents move data *only when needed, only to those who need it*, and *only in the form that they need it***

**iaC Agents *adapt information flow and presentation* based on users’ changing needs, settings, technologies, priorities**

*“Agents” are software applications that act autonomously on behalf of a single individual

# iaC-Managed Communications System

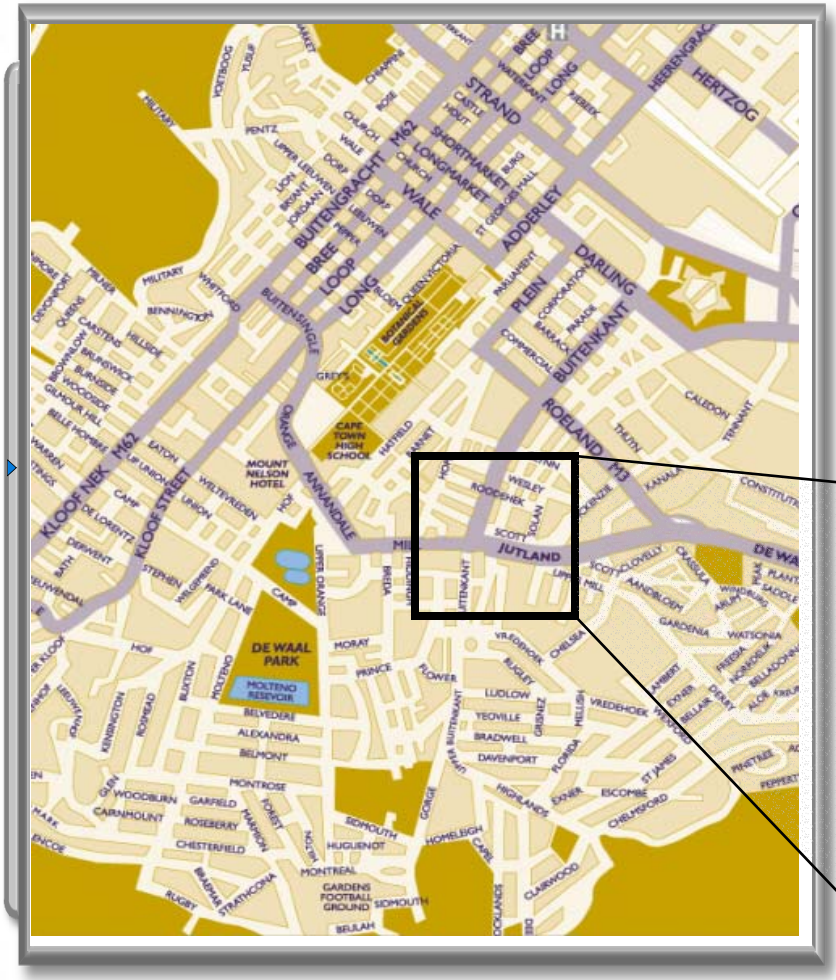


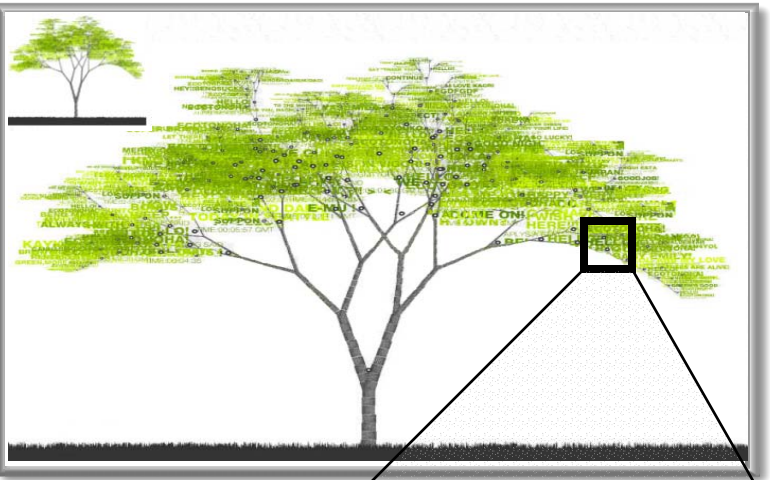
# iaC Communications Interface

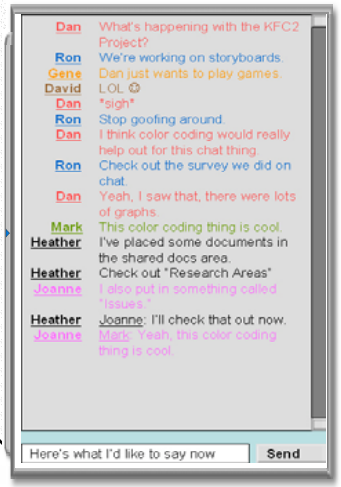
## Single Integrated Interface

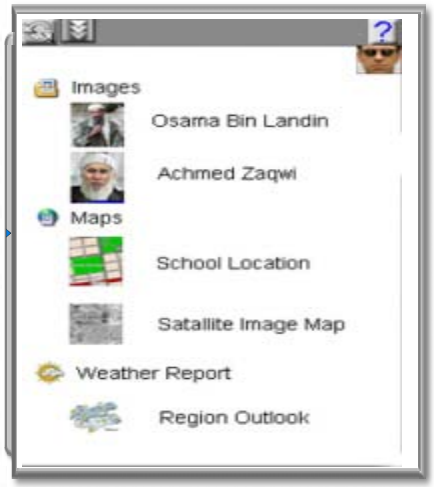
- *All communications* would be routed through / displayed in an iaC-managed communications interface
  - » Graphical displays (COP, maps, satellite images, drawings, whiteboards, etc.)
  - » Text (email, chat, shared documents)
  - » Audio and Video
  - » Phone calls
- iaC would be a shell application running on top of MS Windows that integrates and re-faces existing applications
- Mixing pot / container for all information exchange

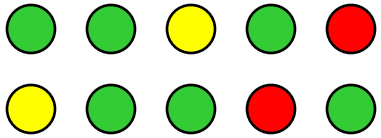

- iaC provides an interface to underlying Agents and integrated applications
  - » Integrated functions
  - » Integrated help
  - » Integrated tools
  - » Link to GIG



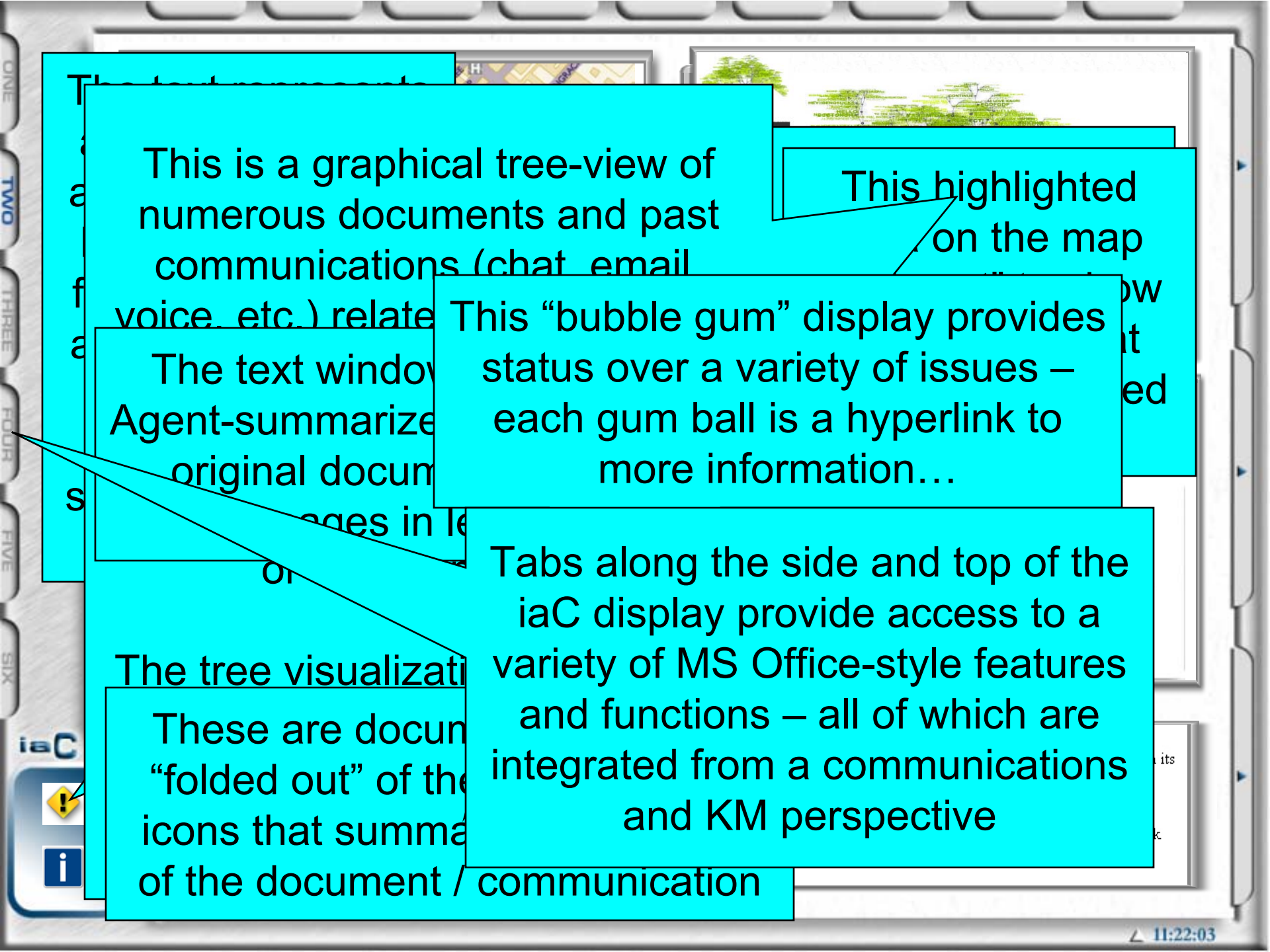





The overall objective of the proposed work is to improve military command and control by enabling the design and development of an intelligent, aware command center that works with its human symbiots to effectively and efficiently acquire, process, and manage data, information, and knowledge. In so doing, we can assign tasks appropriately to human and machine so that each handles the tasks it is most able to perform efficiently and effectively. To achieve this objective, Pacific Science & Engineering Group (PSE) proposes to conduct the necessary work in three phases. *Only Phase I work will be discussed in this proposal.*


This is a graphical tree-view of numerous documents and past communications (chat, email
This highlighted
on the map
This “bubble gum” display provides status over a variety of issues – each gum ball is a hyperlink to more information…
The text windo
Agent-summarize
original docum
Tabs along the side and top of the iaC display provide access to a variety of MS Office-style features and functions – all of which are integrated from a communications and KM perspective
The tree visualizati
These are docun
“folded out” of the
icons that summa
of the document / communication
iaC
11:22:03

# *Envisioned Dynamic iaC Display Space*

This simple demo is borrowed from the web – *it was not developed by PSE* – however, it powerfully demonstrates the way we envision certain aspects of the display adapting to the focus of the user.

Click the icon on the right to start the movie.

# *Just a few of the many iaC payoffs…*


1. All communications / visualizations handled through a single, integrated interface
2. Need to determine best way to communicate with someone (e.g., phone, email, chat, sharing documents, etc.) is eliminated
3. High-priority messages handled / routed / transmitted based on priority
4. Determining who might benefit from new information is facilitated by "suggested recipients" lists – and may include people / organizations totally unknown to sender
5. Communications are "decomposed" by Agents – only new / unique information is transferred
6. Potential collaborators / topical expertise can be quickly and accurately identified across the entire system
7. Displays / visualizations adapt to changing situation and user requirements
8. Communication path / format automatically adapts to each communicator's available technology / bandwidth
9. Data fusion / organization / archiving / KM is done centrally – and is available to all as needed
10. Organizational structure / cultural inhibitions / social network boundaries can alternately be benefited from – or circumvented
11. Multi-level security / access control can be afforded by Agent filtering

# *iaC Vignettes* / Sample Use-Cases*


Typical $C^2$ communications / knowledge exchange situations are being used to highlight relevant issues and iaC benefits:

- Vignette One: High-level status briefing.
- Vignette Two: Problem identification, collaboration, analysis, and response selection.
- Vignette Three: Priority Information Dissemination – Big "Pipe" to "Little Pipe" – Mixed Path / Info Conversion / Security Sanitation Issue ("Black Source" to Command Center Ethernet to Secure Radio Traffic)
- Vignette Four: Information from the Field – One to Many…
- Vignette Five: Coalition Information Exchange
- Vignette Six: Command Center Musical Chairs…

* See Speaker Notes for more detailed description of Vignettes.

# *Relevant Research Areas …*

- Improving speed, efficiency, and effectiveness of information transactions
  - Requests for information
  - Information produced / made available
- Representing change and implications within a store of information
- Accommodating differences in information requirements between different echelons
- Knowledge Management of large stores of information and Knowledge Representation of fused, processed, filtered information

# *Future iaC Technologies and Implementations Currently Under Development …*


Templates to facilitate rapid & consistent information production, exchange, and “story building”

Agents to off-load user of time-consuming “administrative” tasks

Advanced, change awareness, assisted attention focus, status, and alerting technologies

Advanced visualizations of large, complex information spaces to facilitate rapid navigation & assimilation

Agents to tailor content to different classes of users and afford improved Bandwidth Management

Tools to facilitate integration of tactical and non-tactical information systems

# *Where iaC goes from here …*


- Continue development and refinement of iaC concepts
  - Supported by iterative design- and implementation-focused “mini-studies”
- Develop functional, integrated interface with supporting agent and profile technologies
- Iteratively assess and validate with real $C^2$ personnel in “live” command centers
- Pursue necessary teaming relationships and nurture transition opportunities
- Explore non-military $C^2$ environments to identify easy / sensible transition opportunities

# *Comments / Discussion / End*

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