

Specifying Organizational Policies and Individual Preferences for Human-Software Interaction

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Etiquette for Manned Space Operations

- Etiquette: practices and forms prescribed by social convention or authority *American Heritage® Dictionary of English Lang, 4th Ed.*
- Specialized workplace etiquette: effectiveness of participants and their acceptance by others
- Manned space operations is organized hierarchically
 - A single line of command between levels
 - A succinct vocabulary for communicating between levels
 - Roles determine who is authorized to manage a system or function
 - Protocols for each role define
 - What information about a system should be monitored
 - When system changes should be communicated to level above
 - What commands can be passed down the hierarchy
- Objective: extend manned space operations etiquette to include remote, distributed teams of humans and software control agents

Future Manned Space OPS Organization

Inside Vehicle/Facility

Water Control



Air Control



Outside Vehicle/Facility

Robot



Automated agents control without human intervention most of the time

- Perform routine control operations
- Manage anticipated failures

Robot



Crew 1



Crew 2



Crew 3



Future Manned Space OPS Organization

Inside Vehicle/Facility

Water Control



Air Control



Outside Vehicle/Facility

Robot



Humans perform tasks other than control most of the time

- Located remote from the control system
- On-call to handle anomalies
- Interleave occasional control task with other tasks

Robot



Crew 1



Crew 2



Crew 3



Future Manned Space OPS Organization

Inside Vehicle/Facility

Water Control



Air Control



Outside Vehicle/Facility

Robot



Human role in control

- Maintain situation awareness to handle unexpected situations & detect long-term performance changes
- Intervene in control to respond to unexpected situations & to perform tasks not easily automated

Robot



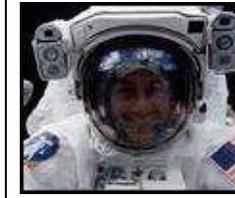
Crew 1



Crew 2



Crew 3



Space OPS Examples: Prescriptions & Proscriptions

Communication

- Don't distract others with unimportant information
- Don't interrupt others unless communication is urgent
- Speak out when have something important to say

Action

- Behave predictably for your roles (set expectations)
- Take initiative to react in situations within your authority
- Recognize and respect authority of others
 - Conform to precedence in decision-making
 - Accommodate authority changes when roles change
- Take appropriate but conservative action (e.g., safe system vs fix system)
- In uncertain circumstances, cause no harm

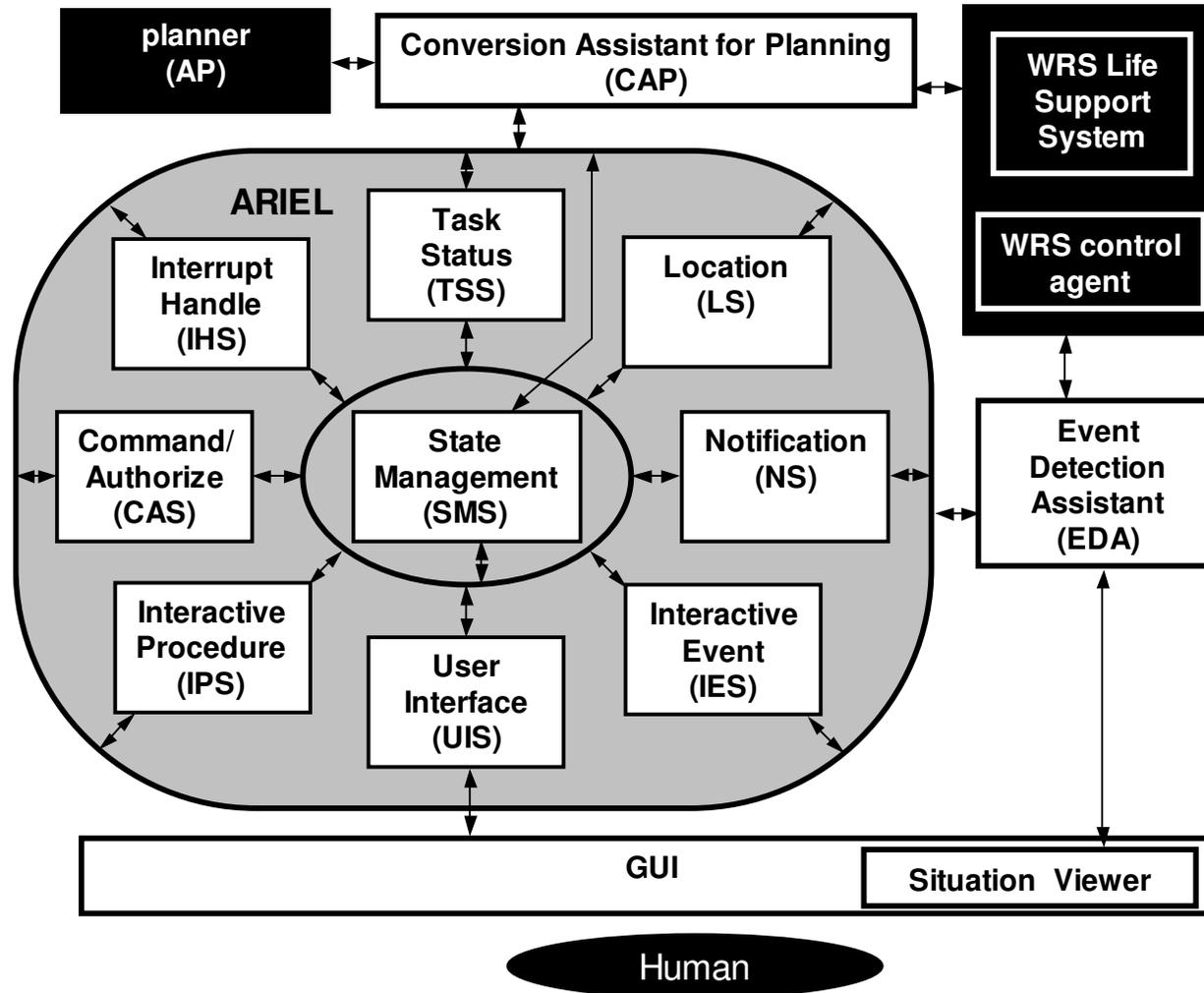
Defining an Etiquette for Distributed OPS

- Ensure that team members are notified of significant operational events in an appropriate manner
 - Approach: encode protocols for notifying humans of operational events from control agents & notices from other team members
 - Specify conditions determining *who* should be informed of an event
 - Describe *how* to inform interested personnel of events
 - Managed by organization to ensure consistent treatment of all members holding the same role
- Enforce consistent, reliable remote commanding
 - Approach: specify the allocation and authentication of control authority according to assigned roles and situational needs
 - Avoid adverse interaction among concurrent commands from different agents
 - Ensure transitions in control authority happen properly

Agents for an Organizational Etiquette

- Approach: develop a proxy agent that encodes the protocols of the organizational etiquette
 - Control responsibilities are allocated to group members based on roles
 - Roles and activities of group are coordinated by centralized group plan that manages limited shared resources
 - Unplanned actions conducted by group members are coordinated to minimize interference with the ongoing activities
- Proxy agents are called Attentive Remote Interaction and Execution Liaison (ARIEL) agents
 - ARIEL acts as liaison for user to facilitate interaction with control agents & other humans to perform tasks for assigned roles in organization
 - ARIEL agent serves single user by providing services to help achieve group goals according to group protocols
 - Services are defined independent of a specific human but are configurable by the user

Architecture of ARIEL Agent



Encoding the Organizational Etiquette

- Notification Service: filters and annotates events received from other humans or agents in organization
 - Ensures proper team members are notified of important changes in situation or important notices from other agents in group
 - Matches means by which team members are notified to their location, activities, and assigned roles
 - Supports user preferences, but preferences are not permitted to override or compromise organizational policies
- Command and Authorization Service: *will* encode an etiquette for remote commanding
 - Determines if user is authorized to issue command before commanding is enabled
 - Manages allocation of control authority to avoid conflicts with other agents who are commanding
 - Reconfigures automated control at transitions in control authority
 - To partial autonomy where conflicting automated tasks are suspended
 - To full autonomy when human commanding is complete

Notification:

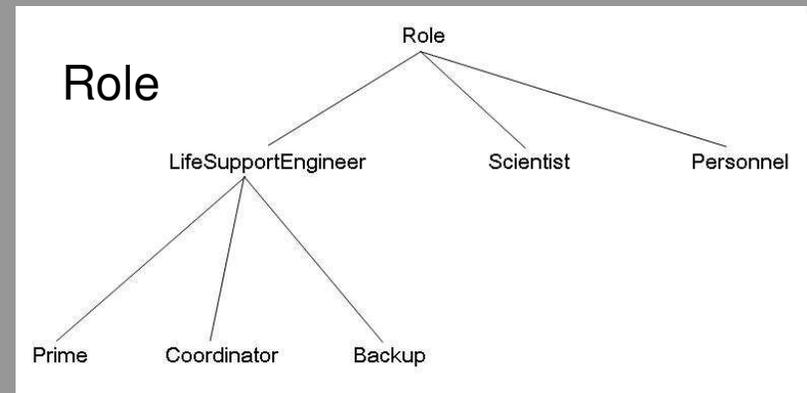
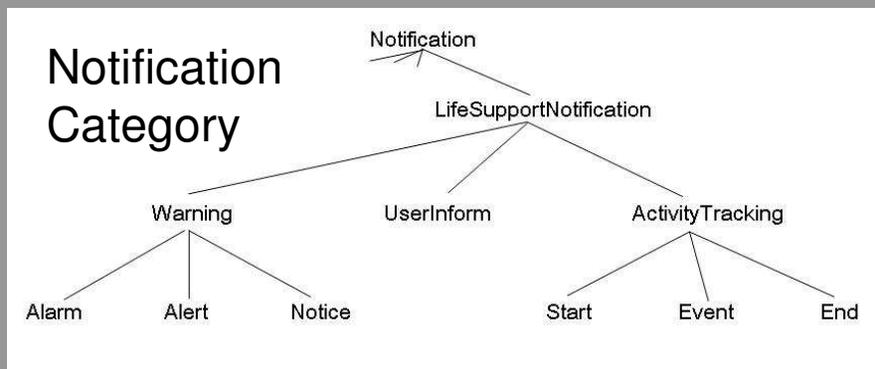
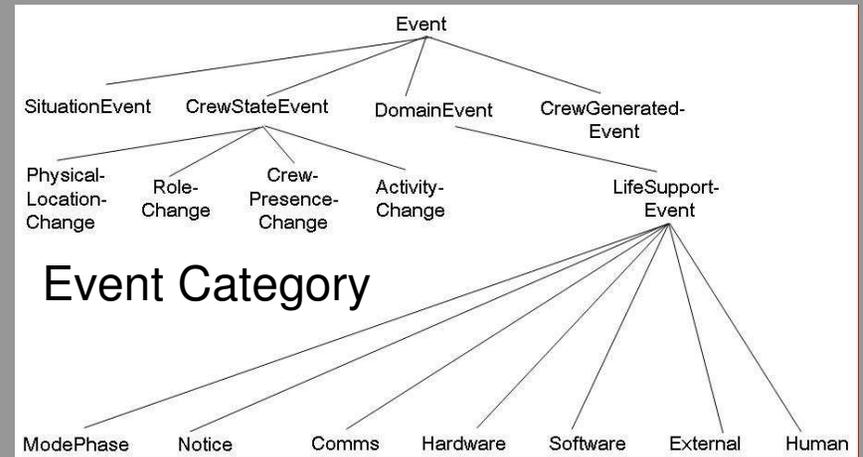
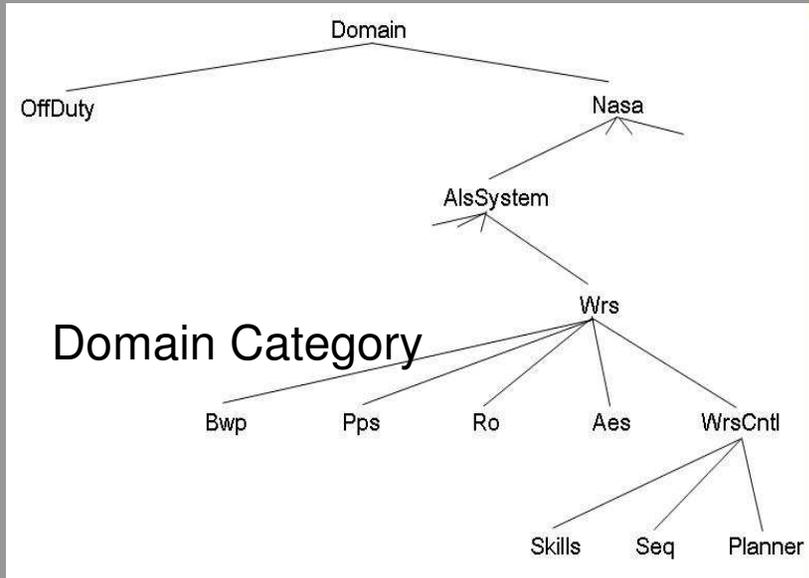
Communicating in Organizational Context

- ARIEL notifies user of control events and agent notices
 - Changes in role alter human information requirements
 - Notice specifications are defined for each role a human takes
 - When roles change, automatically update specs in effect
 - Individual preferences are overlaid on group role requirements without compromising them
 - As a result, multiple specs may hold for each event passed
 - Notification Service: matches incoming events to notice specs
 - User Notification Context determines which specs apply based on user roles and other user state information
 - Notification Conditions determine what events are passed based on event categories, domain categories, notification categories, etc.
 - Notification Directives determine how to inform its user based upon user accessibility and availability (i.e., presence)
 - Location Service: assesses human *presence*

Notice Conditions: What Events Pass

- Match event content to conditions represented as a set of triplets
 - Property of a notice
 - Matching operation
 - Value to match against
- Example
 - Given a set of properties
 - time = May 1, 2002, 13:01:40 CST
 - subject = LORC
 - urgency = HIGH
 - Define filters using these properties
 - time \geq January 1, 2002, 00:00:00 CST and
 - subject equals-string-match “LORC” and
 - urgency greater-than-ordinal “MEDIUM”

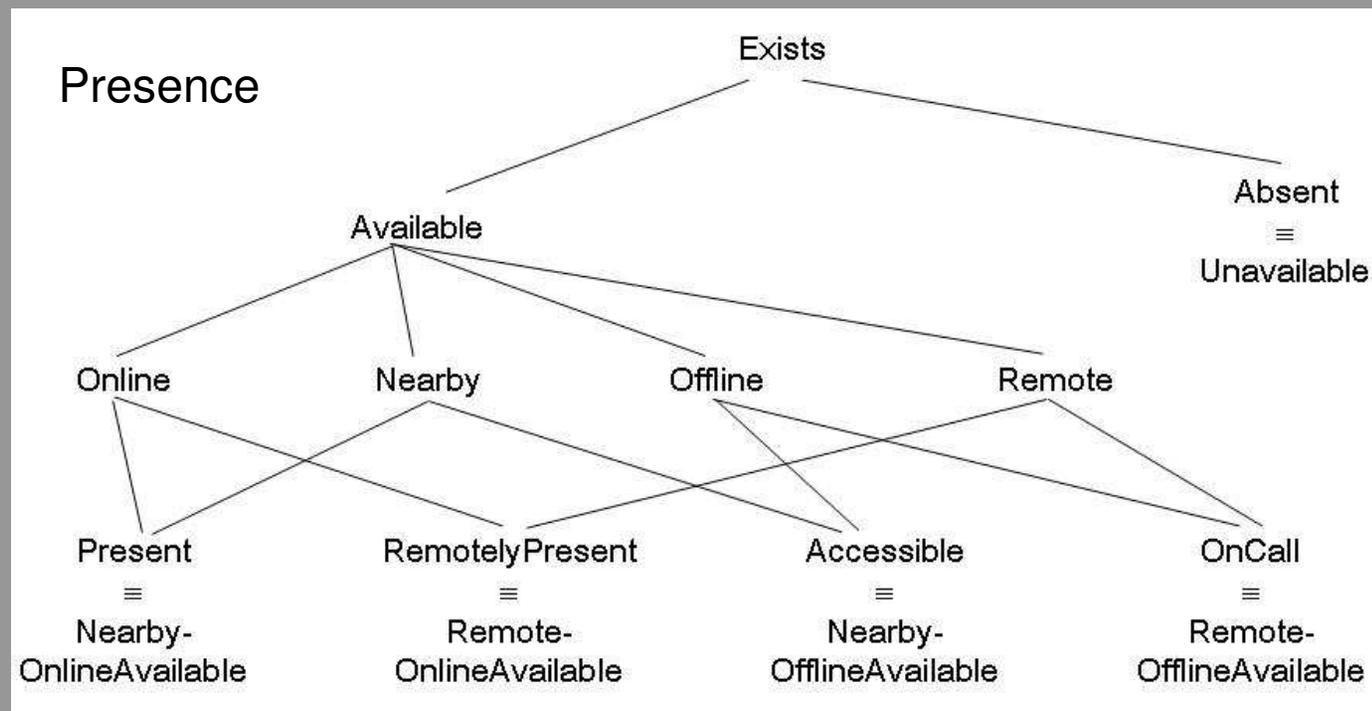
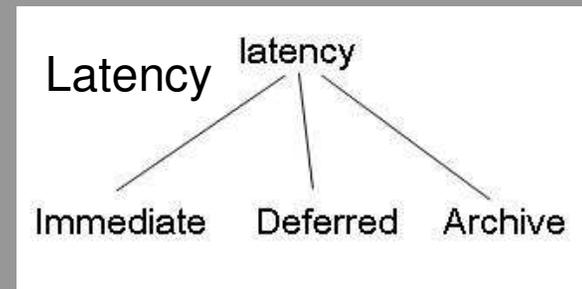
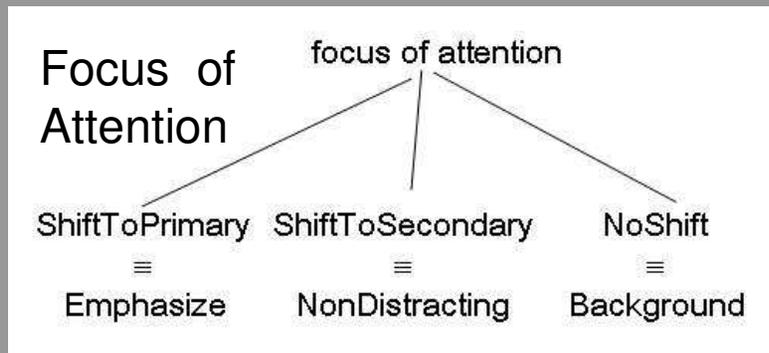
Notification Filters can use Domain Language



Notification Directive: How to Inform User

- Notice spec associates a filter condition with a directive in one or more of these categories
 - **Pass/Prevent:** Determine which notices should be brought to a user's attention, which should be filtered
 - **Notification Saliency:** Annotate notice with information describing how to present it to the user
 - Latency: how soon the user's attention should be drawn to the notice
 - Focus-of-attention: how emphatically the user's attention should be drawn
 - **Modality:** Associate selected modalities (e.g., pager, display) with notices; more urgent notices use more aggressive channels
 - **Modality Conditions:** Check user's current state (i.e., presence) to determine appropriate modality
- Use modalities: pager, display, display-queue, email, & archive

Ontologies for Notification Directive



Examples

for Domain Events

Notice condition ⇒ Notice directive

Assigned to/by	Event Category	Domain Category	Notification Category	Urg	Latency	Focus of Attention	Crew Presence	Modality
ORG { PRIME/Org (covers LORC/RORC) BACKUP in WaterLab/Org (covers LORC/RORC) COORD/Org. (covers LORC/RORC)	Comms	WrsCntl	Warning	L/M/H	immed	primary	online offline	DISPLAY PAGER, D-QUEUE
	Comms	WrsCntl	Warning	L/M/H	immed	primary	online offline	DISPLAY PAGER, D-QUEUE
	Comms	WrsCntl	Warning	L/M/H	immed	secondary	online offline	DISPLAY D-QUEUE

PRIME: WRS control communications warnings are passed with immediate latency and primary focus of attention

If user is online, show notice on ARIEL display

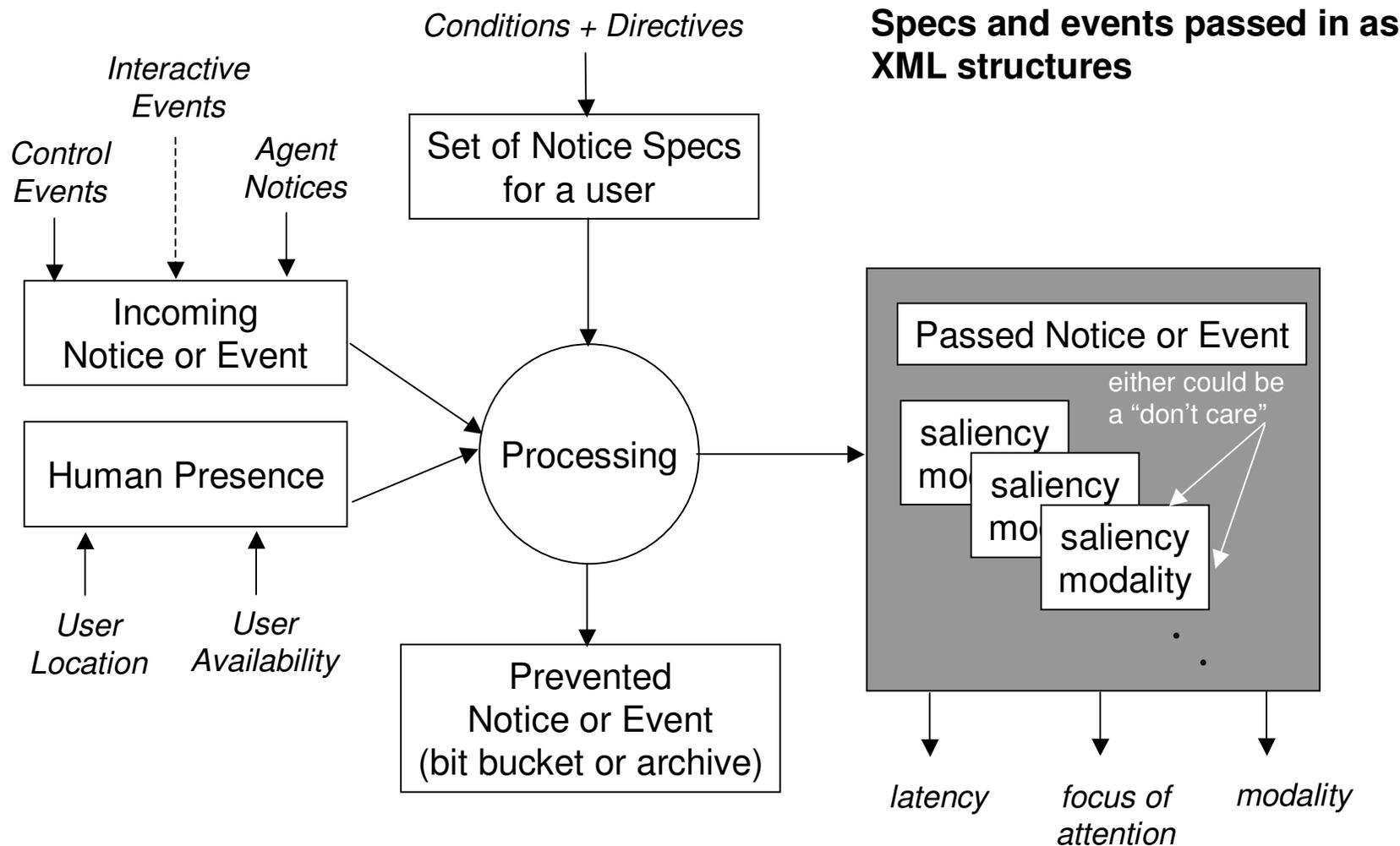
User preferences can add a modality, decrease the latency, or increase focus of attention specified in organizational specs

User preferences cannot remove a modality, increase latency, or decrease focus of attention specified in organizational specs

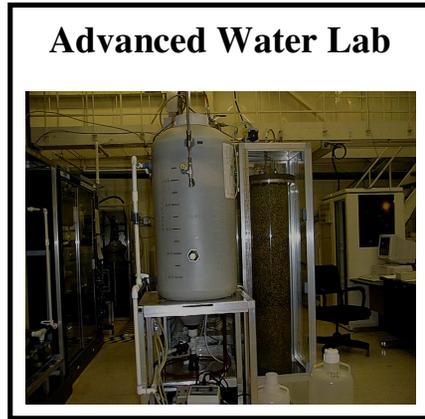
If user is online, show notice on ARIEL display

If user is offline, queue for display when logs back in

Processing of Notification Specifications



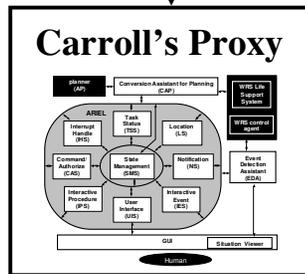
Example: Advanced Water Lab OPS



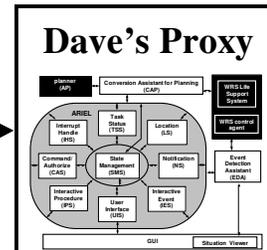
Control events,
commands

Control events,
commands

Control events,
commands



Carroll's Office

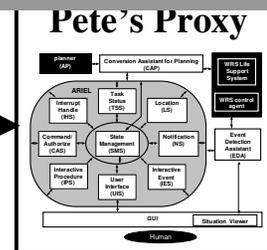


Dave's Office



Scenario

- Anomaly in the Water Lab causes automated control system to safe water processing
- Prime is notified of anomaly via page (offline) and requested to respond
- Prime fails to respond to problem in timely manner
- Backup is notified of anomaly (online) and requested to respond
- Backup travels to Water Lab and solves problem



Pete's Office



Communication

- o Proxy-Control
- o Proxy-Proxy

Use of Latency and Focus of Attention

- Change the way information is communicated from ARIEL to user when annotations are more salient
 - Annotate message to pager with response urgency (e.g., 911 page)



- Change icon to reflect urgency of response
 - Change icon to reflect importance of incoming information
 - Activate audio to draw user's attention to ARIEL interface
- Don't change interface when incoming information has less salient annotations

Summary

- Encoded an etiquette for interaction among humans and control agents performing remote, distributed space operations
 - Base etiquette on current operations combined with experience in deployed automated control agents for crew life support
 - Develop new rules and policies required for humans and automated software agents to work together
 - Make changes to the existing etiquette for human-human interaction for remote operations
- Investigating use of proxy agents that support this etiquette for human-software interaction
 - Implemented services for event notification and alerting
 - Plan to develop service for coordinating distributed, remote commanding