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MULTI-LEVEL USER MODELING IN GIFT TO SUPPORT COMPLEX LEARNING TASKS

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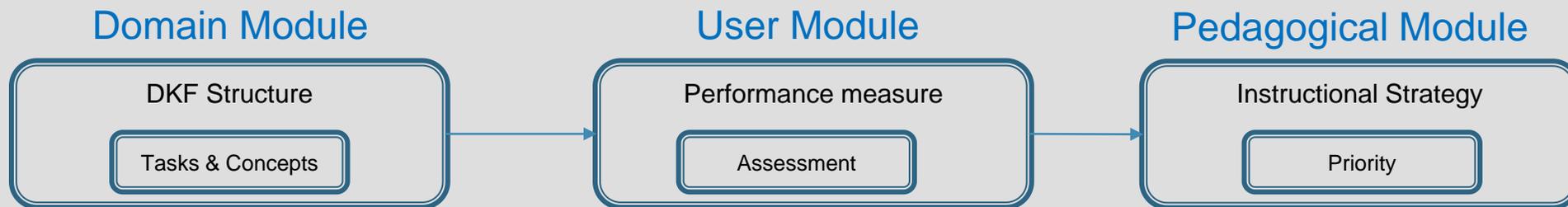
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Outline

- Introduction
- UrbanSim
- Hierarchical Task Model
- Multi-level Hierarchical User Model
- Competence and Trend
- Instructional Strategies
- Implementation of Multi-level user Model in UrbanSim

Complex Problem Solving & Decision making Tasks

- Complex tasks can be broken into subtasks
 - Subtask solutions generates overall solution
- Requires advanced reasoning, thinking, and decision making skills
- Can be problematic for novice learners
 - To Provide personalized and adaptive feedback, our goal is to extend the user models in GIFT system.



UrbanSim

Our environment: UrbanSim

- UrbanSim is a game-based learning environment to teach counterinsurgency operations to Army training officers.
- Developed by Institute of Creative Technologies, University of Southern California and U.S. Army Research Lab.
- UrbanSim responds to user's actions based on the stories created by U.S. Army battalion commanders



Counterinsurgency (COIN) Doctrine

- COIN efforts are directed to a final goal, that is
 - Make Host-nation government stand on its own
 - Create institutions necessary to provide governance and support economic development
 - Host-nation Governments should have the final responsibility to solve their own problems.
- The doctrine adopted by US Army to implement COIN operations is Clear-Hold-Build (CHB)
 - Clear - military forces *clear* an area of insurgents.
 - Hold - focus on *holding* the cleared area and preventing further insurgent infiltration.
 - Build - focus on *building* up the area's government, police forces, and infrastructure such that the local population is able to safeguard the area independently, develop local governance, and focus on economic improvement.

Area of Operation (AO) Overview

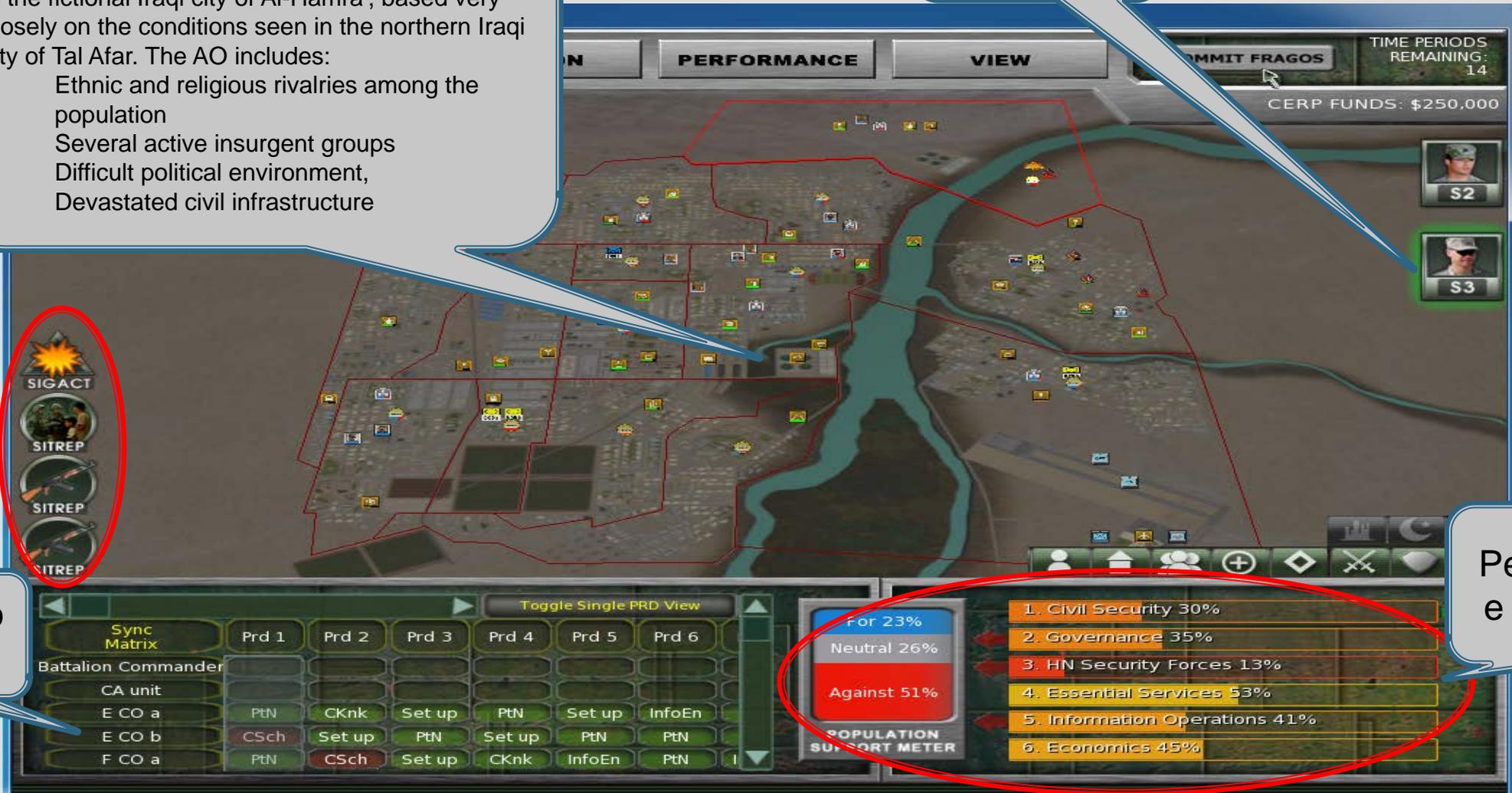
The Area under operation (AO) , 15 regions, is set in the fictional Iraqi city of Al-Hamra', based very loosely on the conditions seen in the northern Iraqi city of Tal Afar. The AO includes:

- Ethnic and religious rivalries among the population
- Several active insurgent groups
- Difficult political environment,
- Devastated civil infrastructure

Reporting officers

- SIGACT
- SITREP
- SITREP
- SITREP

11 Units to command



PERFORMANCE VIEW

COMMIT FRAGOS TIME PERIODS REMAINING: 14

CERP FUNDS: \$250,000

S2

S3

POPULATION SUPPORT METER

Unit	Prd 1	Prd 2	Prd 3	Prd 4	Prd 5	Prd 6
Battalion Commander						
CA unit	PtN	CKnk	Set up	PtN	Set up	InfoEn
E CO a	CSch	Set up	PtN	Set up	PtN	PtN
E CO b	PtN	CSch	Set up	CKnk	InfoEn	PtN
F CO a						

For 23%
Neutral 26%
Against 51%

- Civil Security 30%
- Governance 35%
- HN Security Forces 13%
- Essential Services 53%
- Information Operations 41%
- Economics 45%

Performance feedback

UrbanSim

UrbanSim

FILE MISSION PERFORMANCE VIEW

COMMIT FRAGOS TIME PERIODS REMAINING: 15

CERP FUNDS: \$240,000



S2

S3

Legend:

- Sunni
- Shiite
- Kurdish
- Other/Mixed

S W E A T T M F

8

UrbanSim

MISSION BRIEFING

Mission Overview | Mission Analysis | Mission Plan

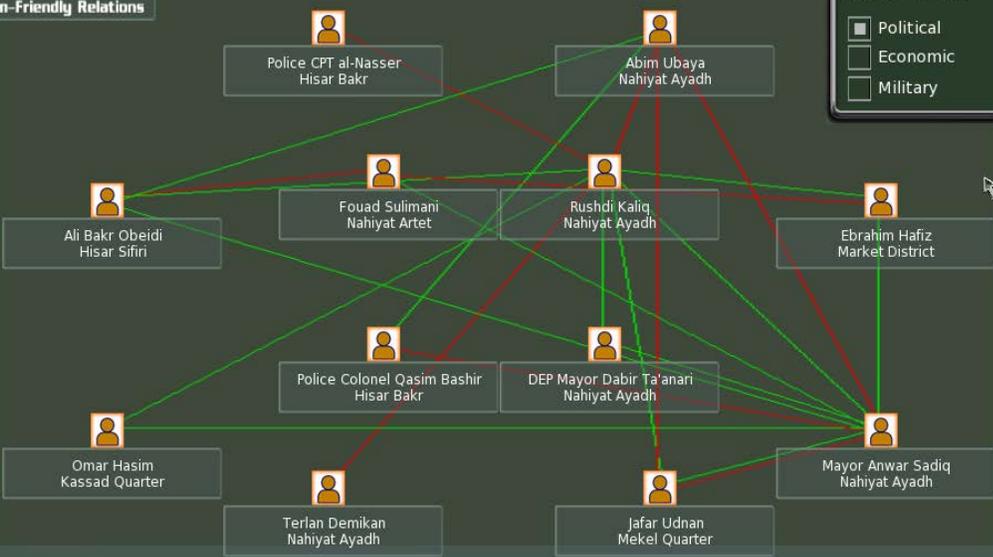
Scenario: AlHamra2

List of Available Units | Network Overlay | Other Intel

Friendly Relation
 Non-Friendly Relations

Network Filters

- Political
- Economic
- Military



Exit | Continue

UrbanSim

MISSION BRIEFING

Mission Overview | Mission Analysis | Mission Plan

Scenario: AlHamra2

List of Available Units | Network Overlay | Other Intel

Name	Location	Ethnicity/Religion	Occupation
Abim Ubaya	Nahiyat Ayadh	Shia Arab	Shiite Imam, Head of M
Ali Bakr Obeidi	Hisar Sifiri	Sunni Arab	School Superintendent
Battalion Commander	Nahiyat Musalla		
DEP Mayor Dabir Ta'anari	Nahiyat Ayadh	Sunni Arab	Deputy Mayor
Ebrahim Hafiz	Market District	Sunni Arab	Owens large retailer; Me
Fouad Sulimani	Nahiyat Artet	Sunni Arab	Hospital Administrator
Jafar Udnan	Mekel Quarter	Sunni Arab	Sunni Cleric
Mayor Anwar Sadiq	Nahiyat Ayadh	Sunni Arab	Mayor
Omar Hasim	Kassad Quarter	Sunni Arab	Industrialist, Cement F
Police CPT al-Nasser	Hisar Bakr	Shia Arab	IP Captain
Police Colonel Qasim Bas	Hisar Bakr	Shia Arab	IP Colonel

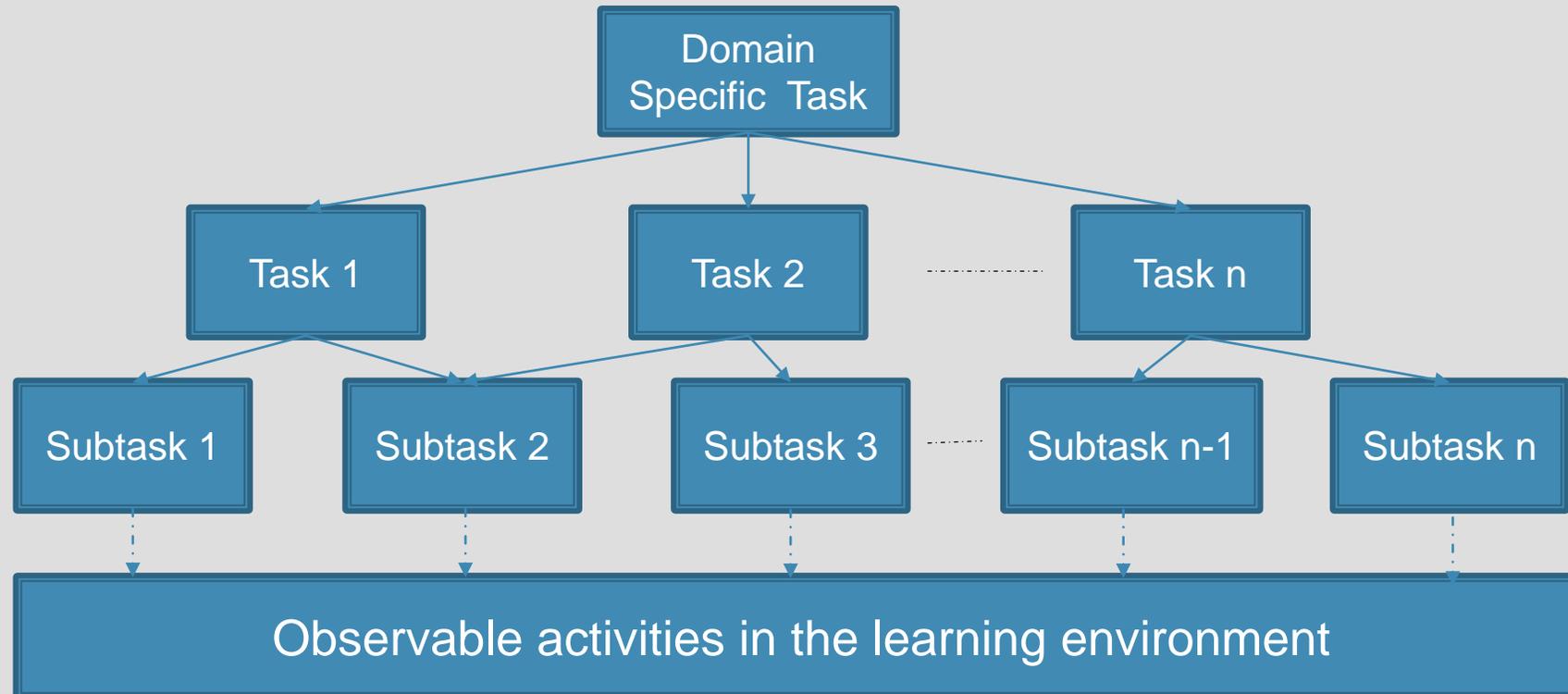
- Individuals
- Groups
- Structures
- SITREPs
- SIGACTs

Exit | Continue

Extending the User Model in GIFT Domain Module (DKF)

Hierarchical Task Model Structure

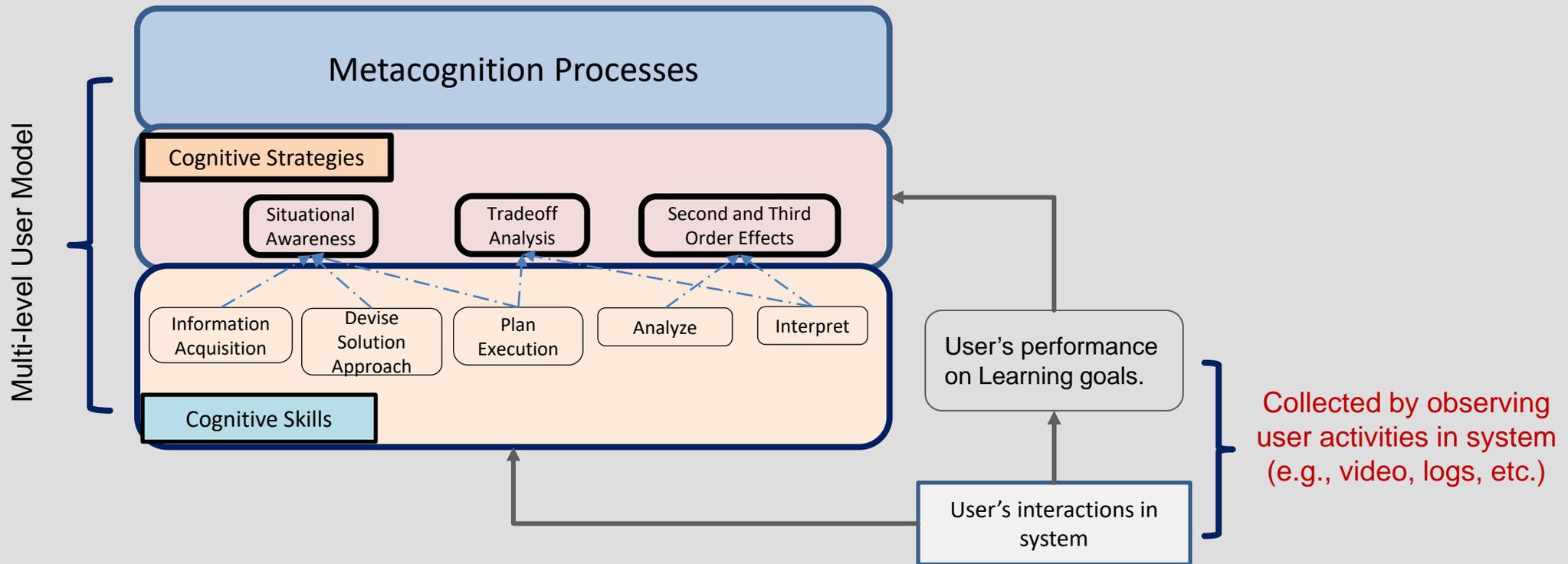
- Task model provides a successive, hierarchical breakdown of the primary tasks (learning goals) into their component subtasks in the learning environment (LE)
- At the lowest levels of the hierarchy, the tasks are linked to the observable actions in the LE.



User Behaviors

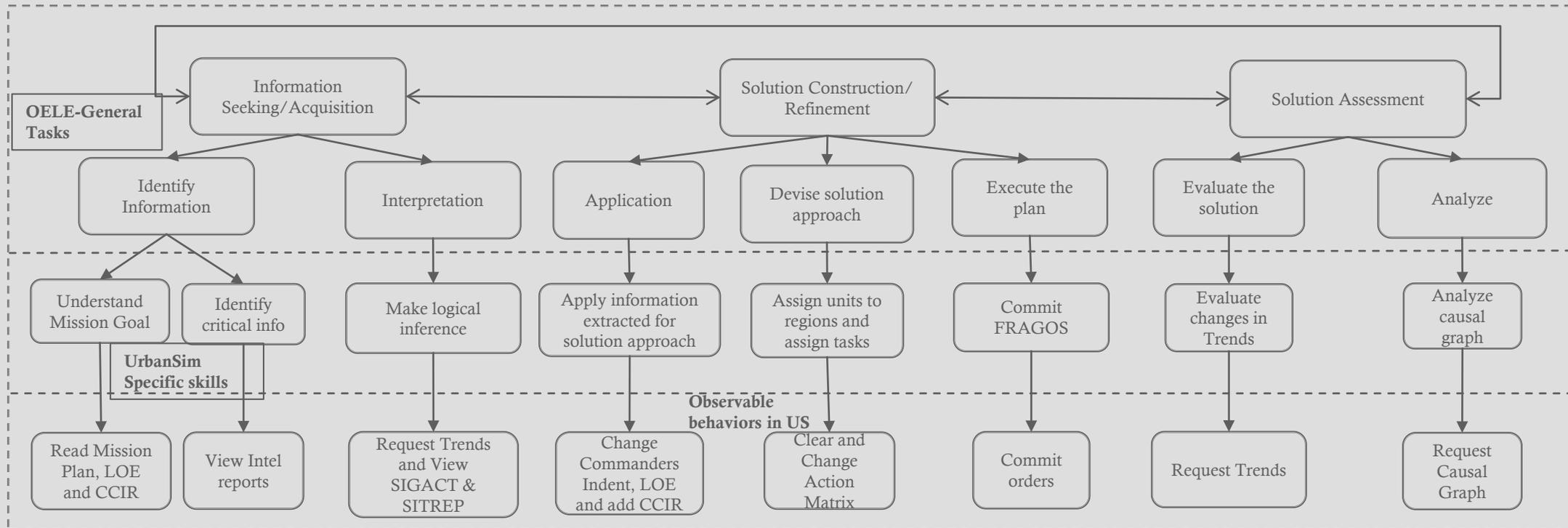
- Cognitive skills – linked to user’s observable actions through which they can accomplish sub tasks and tasks toward achieving their overall problem solving goals
- Strategies - Conditional – describes when a sub-task or actions (cognitive skills) or even a sequence of cognitive skills should be invoked to work toward a problem solving task
 - Strategies help the user formulate partial plans or refine an existing plan step (sub goal) to more detailed sequence of steps (or skills)
- Metacognitive process – covers goal setting, planning, monitoring, evaluation and reflection
 - Difficult to track because lot of the thinking related to these activities happens in users’ heads

Proposed Multi-level Hierarchical User Model



Task Model for UrbanSim

- Actions: users' observable interaction with UrbanSim
- UrbanSim permits 43 different actions related to acquiring information in the COIN scenario.



Learning Measures in UrbanSim

- Learning Goal: Learn COIN – CHB Doctrine
 - LOE - measure of students' adherence to the Brigade Commander's intent.
 - Clear Insurgents, Build Infrastructure

- Learning Behaviors:
 - Skills – e.g. interpret, apply and reasoning
 - Strategies – In order to achieve successful COIN doctrine
 - CHB Strategy – how well the regions are transferred from clear to hold to build phase.
 - Situational Awareness - ability to identify and interpret key information in AO to develop a common operating picture (COP).
 - Trade-off analysis - a measure of decision making for choosing current operations, given limited resources such as CERP funds, and units.
 - Second and third-order effects - analyzing and predicting the effects of operations that are compatible with a prescribed end goal.
 - Metacognition – Awareness, Goal setting, Planning, Monitoring progress, and Reflecting

GIFT User Module

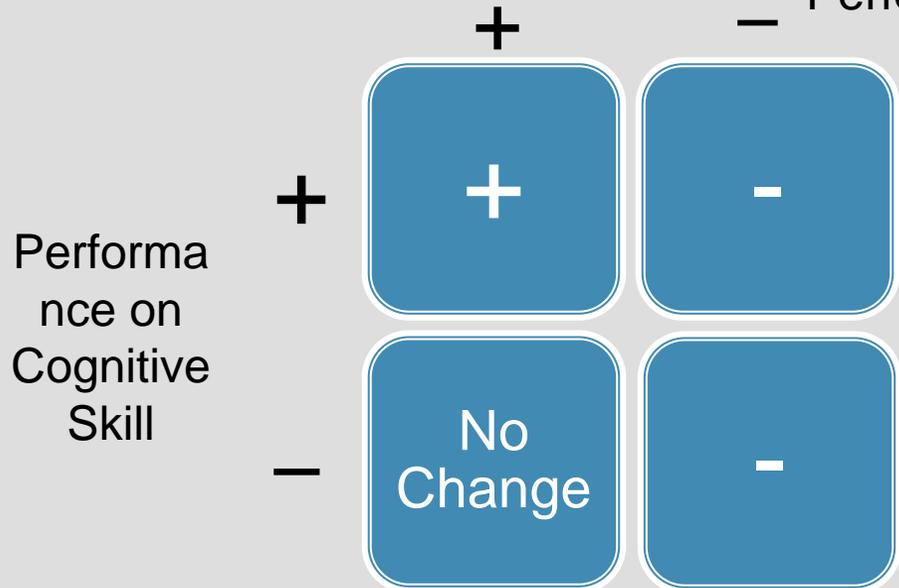
Performance measures

Performance Metrics in Hierarchical User Model

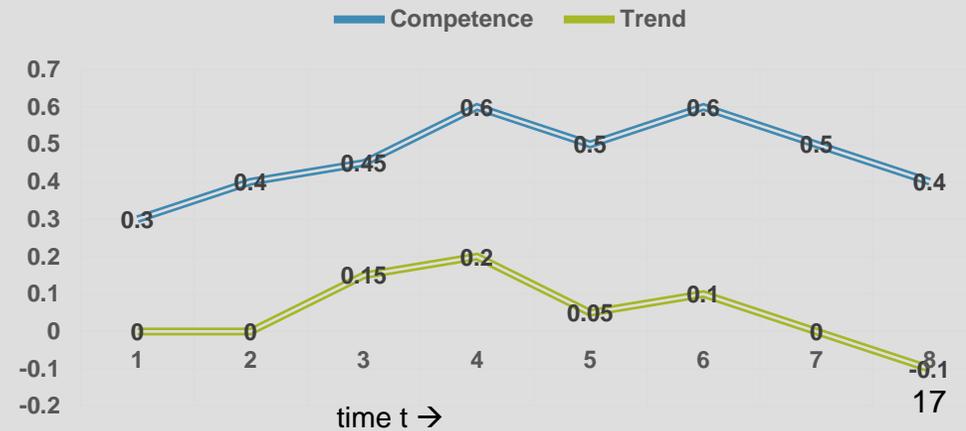
- In complex environments, users' perform multiple tasks, therefore, use skills and strategies multiple times
 - We need to accumulate user's performance over a period of time; Use two measures:
 - Competence: $C_t = C_{t-1} + f(\text{observable actions})$: user's competence accumulated measure*
 - Trend: $T = f((C_t - C_{t-1}), (C_{t-1} - C_{t-2}))$: trend measures recent changes in competence*

[f can be min, max, or avg]

Performance on goal
or sub-goal



COMPETENCE AND TREND OVER TIME



Competence algorithms in UrbanSim

- Competence on cognitive skills are measured based user's interaction with UrbanSim.
 - C_i (Identify) = C_{i-1} (identify) + f (Read mission Plan action, LoE, CCIR, View Intel Reports)
- Learning Goal: Learn COIN – CHB Doctrine
 - Sub goals: Clear insurgents, improve collision support with local government, improve the infrastructure, repair utilities, Improve ISF Military power (MP).
 - Competence (Clear Insurgents) = Avg (MP (insurgent groups))
 - $MP_i = \text{Avg} (MP (JAAS), MP (Kurdish Raiders), MP (Shiite Death Squads), MP (Al-Qassas Brigade))$
 - *Competence on learning goals are extracted form log files.*

Examples

- Cognitive skill – Evaluate at Turn number 5. Current C (Evaluate) = 0.7

$C(\text{Evaluate})_5 = C(\text{Evaluate})_4 + f(\text{Request Trends, Request Population trend analysis, request LoE trend analysis, Set LoE Button})$

for actions at turn 5.

If action in (Request Trends, Request Population trend analysis, request LoE trend analysis, Set LoE Button) and time > 10 seconds

ActionCounter++; - 5

If performance of LoEs₅ != LoEs₄ then - Yes

$C(\text{Evaluate})_5 = \text{avg}(0.7 + \text{ActionCounter}/7)$ - avg(0.7 + 0.714) = 0.707

- Cognitive Strategy – Situational Awareness (SA). C(SA) = 0.6

- $C(\text{SA})_5 = C(\text{SA})_4 + f(\text{Performance in CS and EF, C(identify, Interpret, Apply, Evaluate and Devise)})$

- Performance in CS and EF = 0.6, 0.53 > 0.5

- $C(\text{SA})_5 = \text{avg}(0.6 + \text{avg}(0.63, 0.72, 0.5, 0.707, 0.625)) = \text{avg}(0.6, 0.634) = 0.617$

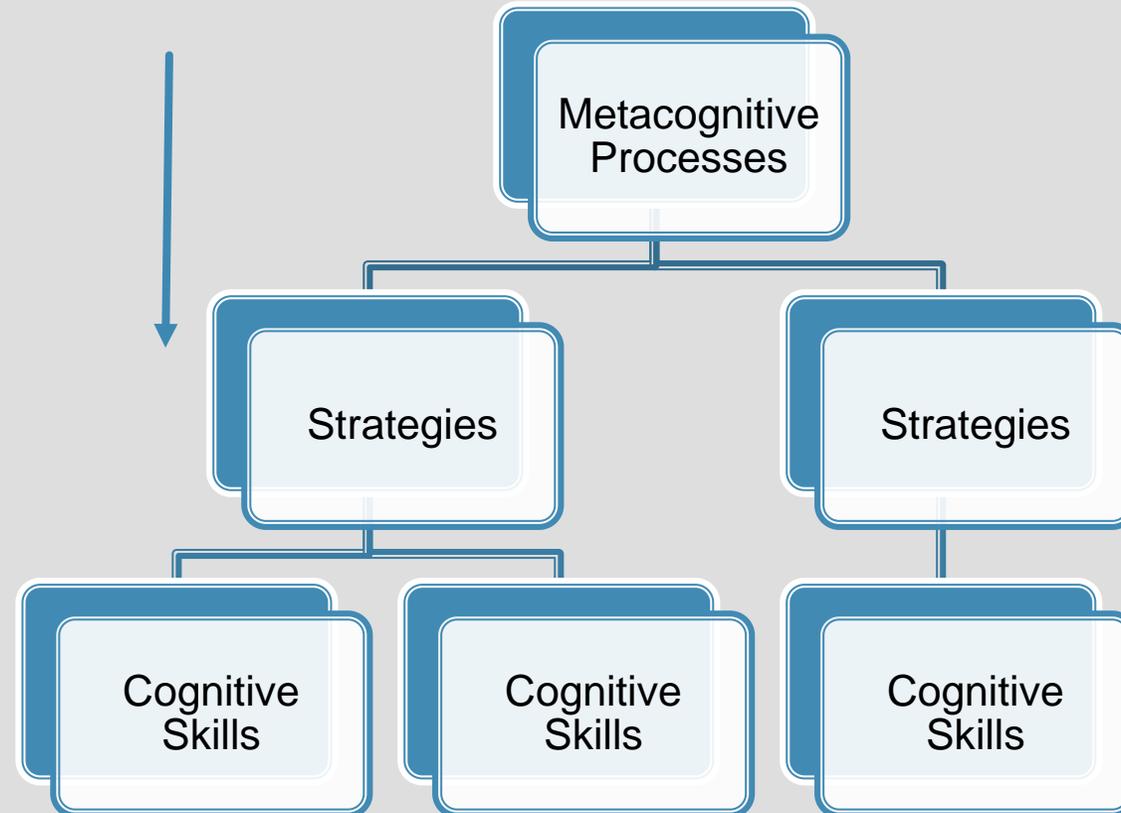
Instructional Strategy Pedagogical Module

Instructional Strategy for multi-level user model

If user requires feedback:
At what level should we provide feedback to user?
What should be the topic of the feedback?

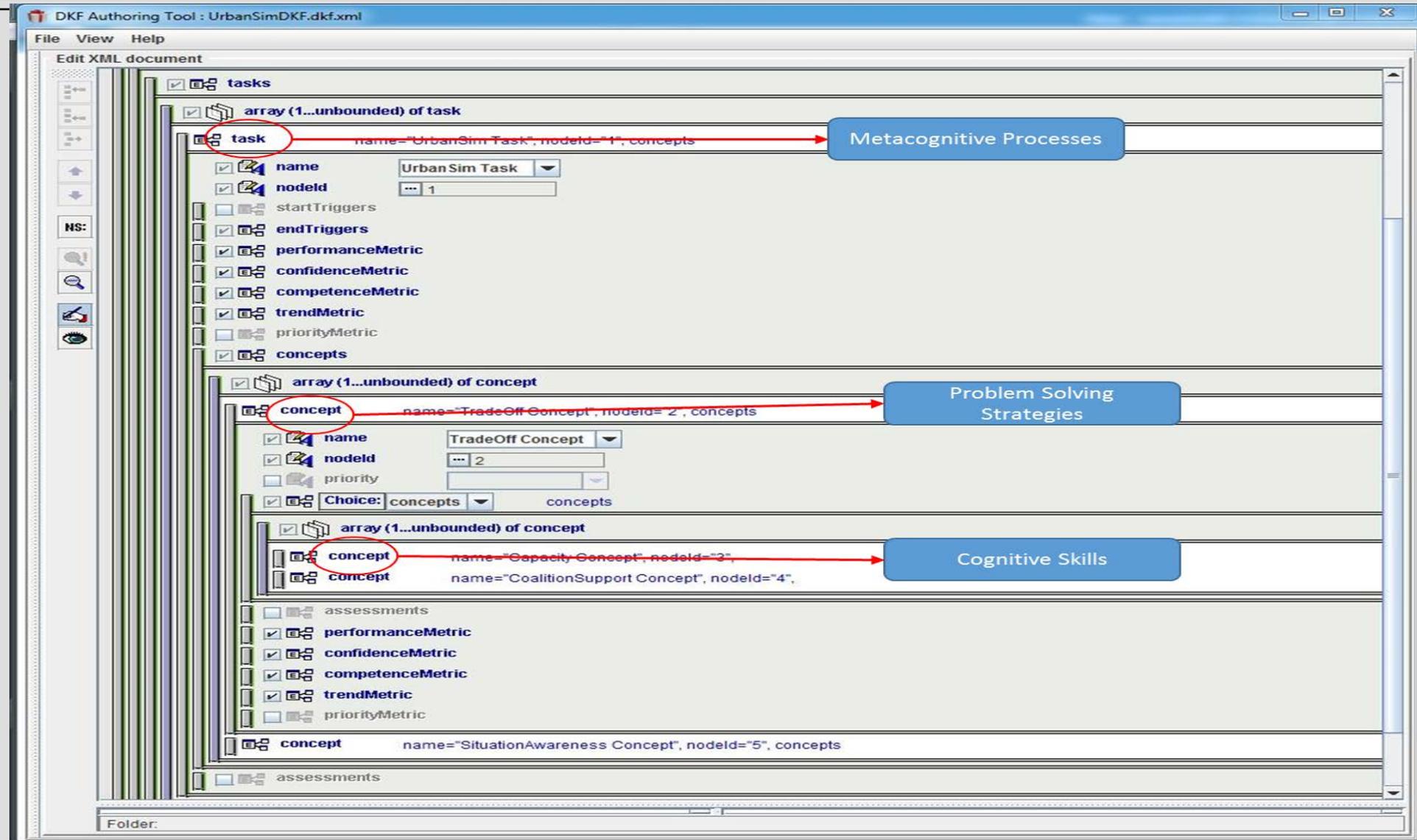
Analyze C and T values of child nodes and picks the child node that has the least competence and a negative or flat trend

If the user's cognitive skills are above threshold then the algorithm focuses on the higher-level selected strategy for feedback.



Implementation of Multi-level user Model in UrbanSim

DKF Authoring Tool



The screenshot displays the DKF Authoring Tool interface for editing an XML document titled "UrbanSimDKF.dkf.xml". The main workspace shows a hierarchical tree structure of XML elements. Three specific elements are highlighted with red circles and arrows pointing to blue callout boxes:

- task** (name="UrbanSim Task", nodeId="1", concepts) is linked to **Metacognitive Processes**.
- concept** (name="TradeOff Concept", nodeId="2", concepts) is linked to **Problem Solving Strategies**.
- concept** (name="Capacity Concept", nodeId="3") is linked to **Cognitive Skills**.

The interface includes a menu bar (File, View, Help), a toolbar, and a left sidebar with various icons. The XML tree shows nested arrays and individual elements with their respective attributes and child elements.

Performance Node Status Tool

Performance Node Status Tool - UrbanSim

Name	Id	Status	Assessment	Confidence	Competen...	Trend	Priority	Time
 CapacitySA Concept	8	running	Unknown	1.0	1.0	1.0	6	21:52:29:601 CDT 05:08:2017
 CoalitionSupportSA Con...	9	running	Unknown	1.0	1.0	1.0	7	21:52:29:622 CDT 05:08:2017
 EffectivenessSA Concept	10	running	Unknown	1.0	1.0	1.0	8	21:52:29:639 CDT 05:08:2017
 InsurgentMiliSA Concept	11	running	Unknown	1.0	1.0	1.0	9	21:52:29:661 CDT 05:08:2017
 MilitarySA Concept	12	running	Unknown	1.0	1.0	1.0	10	21:52:29:686 CDT 05:08:2017
 SituationalAwareness C...	13	running	Unknown	1.0	1.0	1.0	11	21:52:29:717 CDT 05:08:2017
 Clear Concept	14	running	Unknown	1.0	1.0	1.0	12	21:52:29:732 CDT 05:08:2017
 Hold Concept	15	running	Unknown	1.0	1.0	1.0	13	21:52:29:751 CDT 05:08:2017
 Build Concept	16	running	Unknown	1.0	1.0	1.0	14	21:52:29:768 CDT 05:08:2017

- Tool to monitor all performance metrics throughout the simulation

The interface features a top navigation bar with 'FILE', 'MISSION', 'PERFORMANCE', and 'VIEW' tabs. On the right, it displays 'COMMIT FRAGOS', 'TIME PERIODS REMAINING: 13', and 'CERP FUNDS: \$240,000'. The main map area shows a city layout with numerous nodes, each represented by a circular icon with various colored segments and labels like 'POL', 'MIL', 'SOC', 'ECCO', 'INFO', 'RtP', 'InfoEn', 'PtN', 'Set up', 'CSch', 'RtIP', 'InfoEn', 'PtN'. A 'SIGACT' icon is visible on the left. Below the map is a 'SITREP' section with a 'SWEAT M F' indicator. At the bottom, there is a 'Sync Matrix' table, a 'POPULATION SUPPORT METER' showing 'For 23%', 'Neutral 34%', and 'Against 43%', and a list of six categories with their respective percentages and trend indicators.

Category	Percentage	Trend
1. Civil Security	32%	Green Arrow
2. Governance	35%	Red Arrow
3. HN Security Forces	23%	Green Arrow
4. Essential Services	53%	Green Arrow
5. Information Operations	43%	Green Arrow
6. Economics	45%	Green Arrow

Performance Node Status Tool - UrbanSim

Name	Id	Status	Assessment	Confidence	Competence	Trend	Priority	Time
CapacitySA Conc...	8	running	Unknown	0.0	0.642857193...	-0.35714280...	2	22:15:44:761 CDT 05:08:2017
CoalitionSupport...	9	running	Unknown	0.0	0.656800031...	-0.34319996...	3	22:15:44:761 CDT 05:08:2017
EffectivenessSA ...	10	running	Unknown	0.0	0.383333325...	-0.61666667...	4	22:15:44:761 CDT 05:08:2017
InsurgentMiliSA ...	11	running	Unknown	1.0	0.287500023...	-0.71249997...	1	22:15:44:761 CDT 05:08:2017
MilitarySA Concept	12	running	Unknown	0.0	0.180000007...	-0.81999999...	5	22:15:44:761 CDT 05:08:2017
SituationalAware...	13	running	Unknown	0.0	0.287500023...	-0.71249997...	6	22:15:44:761 CDT 05:08:2017
Clear Concept	14	running	Unknown	1.0	1.0	1.0	7	22:15:44:761 CDT 05:08:2017
Hold Concept	15	running	Unknown	0.0	0.300000011...	-0.69999998...	8	22:15:44:761 CDT 05:08:2017
Build Concept	16	running	Unknown	0.0	0.300000011...	-0.69999998...	9	22:15:44:761 CDT 05:08:2017

FILE MISSION PERFORMANCE VIEW COMMIT FRAGOS TIME PERIODS REMAINING: 12 CERP FUNDS: \$240,000

SIGACT **S** **W** **E** **A** **T** **M** **F**

Sync Matrix Toggle Single PRD View

	Prd 1	Prd 2	Prd 3	Prd 4	Prd 5	Prd 6
Battalion Commander						
CA unit						
E CO a	PtN	CKnk	Set up	PtN	Set up	InfoEn
E CO b	CSch	Set up	PtN	Set up	PtN	RtP
F CO a	PtN	CSch	Set up	RtP	InfoEn	PtN

POPULATION SUPPORT METER

- For 23%
- Neutral 34%
- Against 43%

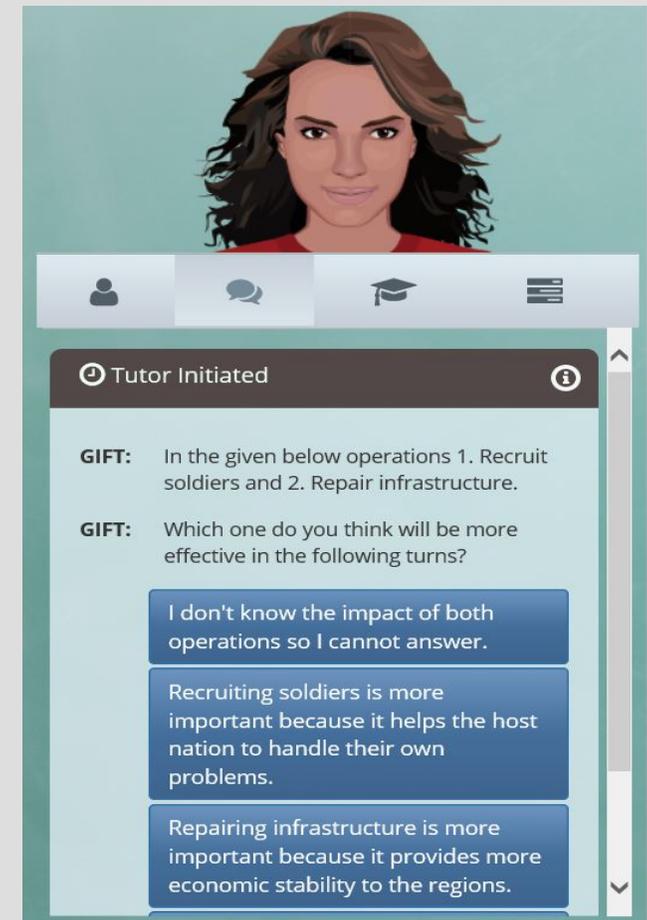
1. Civil Security 35%
2. Governance 29%
3. HN Security Forces 23%
4. Essential Services 53%
5. Information Operations 42%
6. Economics 45%

Performance Node Status Tool - UrbanSim

Name	Id	Status	Assessment	Confidence	Competence	Trend	Priority	Time
CapacitySA Conc...	8	running	Unknown	0.0	0.630952417...	-0.01190477...	2	22:19:02:489 CDT 05:08:2017
CoalitionSupport...	9	running	Unknown	0.0	0.705300033...	0.048500001...	3	22:19:02:489 CDT 05:08:2017
EffectivenessSA ...	10	running	Unknown	0.0	0.383333325...	0.0	4	22:19:02:489 CDT 05:08:2017
InsurgentMiliSA ...	11	running	Unknown	1.0	0.242500007...	-0.04500001...	1	22:19:02:490 CDT 05:08:2017
MilitarySA Concept	12	running	Unknown	0.0	0.229999989...	0.049999982...	5	22:19:02:490 CDT 05:08:2017
SituationalAware...	13	running	Unknown	0.0	0.242500007...	-0.04500001...	6	22:19:02:490 CDT 05:08:2017
Clear Concept	14	running	Unknown	1.0	1.0	1.0	7	22:15:44:761 CDT 05:08:2017
Hold Concept	15	running	Unknown	0.0	0.300000011...	0.0	8	22:19:02:490 CDT 05:08:2017
Build Concept	16	running	Unknown	0.0	0.300000011...	0.0	9	22:19:02:491 CDT 05:08:2017

Feedback:

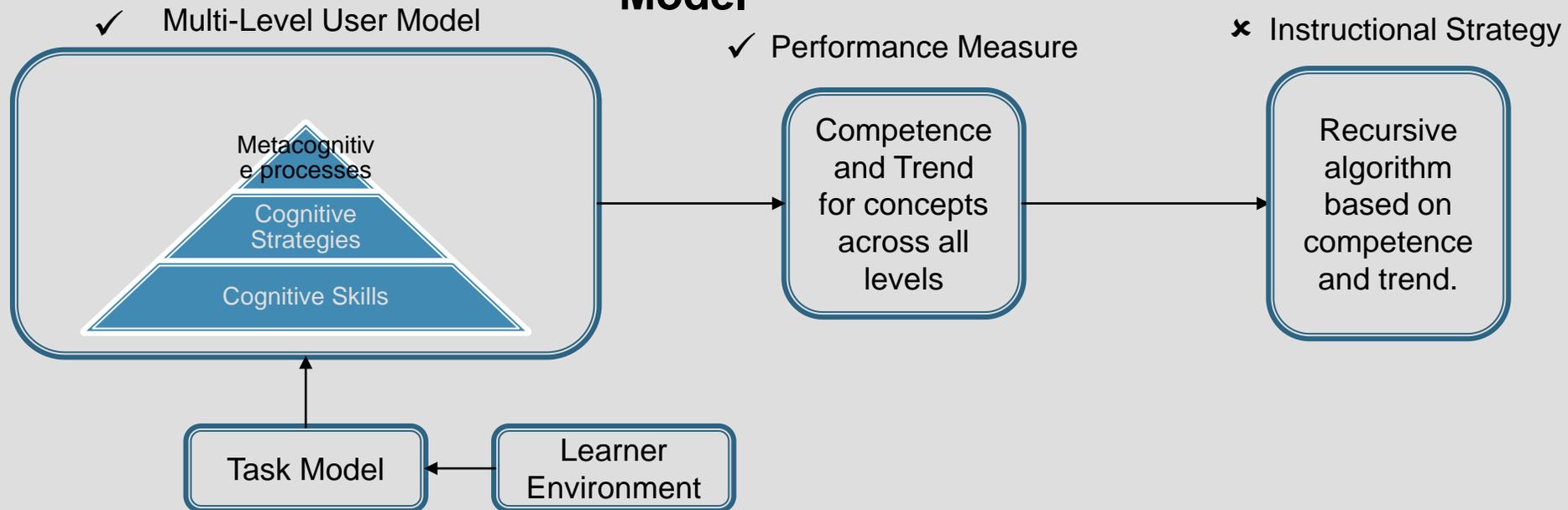
- The current feedback is based on priority and Assessment as displayed (the concept with the least priority and least Assessment is chosen for feedback).
- But, when applied to a hierarchical structure has its limitations as it cannot be applied across different levels of DKF.
- Hence requirement for a recursive algorithm based on competence and trend.



Name	Id	Status	Assessment	Confidence	Competence	Trend	Priority	Time
CapacitySA Conc...	8	running	BelowExpectation	0.0	0.630952417...	0.0	5	22:24:35:812 CDT 05:08:2017
CoalitionSupport...	9	running	AtExpectation	1.0	0.666299998...	0.009499967...	6	22:24:35:812 CDT 05:08:2017
EffectivenessSA ...	10	running	Unknown	1.0	0.383333325...	0.0	4	22:24:35:812 CDT 05:08:2017
InsurgentMiliSA ...	11	running	AtExpectation	0.0	0.197499990...	-0.04500001...	2	22:24:35:812 CDT 05:08:2017
MilitarySA Concept	12	running	AtExpectation	0.0	0.229999989...	0.049999982...	3	22:24:35:812 CDT 05:08:2017
SituationalAware...	13	running	AboveExpectation	1.0	0.400000005...	0.157499998...	11	22:24:35:812 CDT 05:08:2017
Clear Concept	14	running	Unknown	1.0	1.0	1.0	12	22:24:35:812 CDT 05:08:2017
Hold Concept	15	running	Unknown	0.0	0.300000011...	0.0	13	22:24:35:812 CDT 05:08:2017
Build Concept	16	running	Unknown	0.0	0.300000011...	0.0	14	22:24:35:812 CDT 05:08:2017

Conclusion

Extended GIFT User Model



Future Work

- How to identify metacognitive processes?
 - May require dialog with users & user responses will be used along with strategy competence to update metacognitive process competence and trends
 - How do we implement this in the GIFT framework?
- Analyze the discussion among participants in each group.

Thank You