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Ontology-driven Methods and a Framework for Enabling Hybrid Adaptive Team Training using Task and Sensor-based Performance Evaluation

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Outline

- Introduction
- Motivations
- Ontology-Driven Methods for Hybrid Team Adaptive Training
- GIFT Architecture
- Conclusions
- Future Work

Introduction

- Adaptive Training must be intelligently tailored for individuals and units with a focus on optimizing training performance, training efficiency, and transfer of skills to the operational environment
- Training must be tailored based on trainee and team state (cognitive, affective, social, etc.) and to trainee and team task performance
- Barrier: time and cost required to build and maintain complex training applications

Motivations

- Currently, team training scenarios are hand-crafted, static representations of training and mission contexts
- Team training models require the representation of complex information structures
  - Team structures
  - Performance evaluations (both team and individual)
- Lack of robust team training support in GIFT
- Lack of rapid team training development and execution in GIFT

Problem

- Semantic rules of a representation team training applications/tools and the semantic intentions of the training are not easily accessible or documented
- Difficult to determine the semantic content of the team training models
  - We refer to this as the problem of *semantic inaccessibility*.
  - Manifests itself in different ways, including *unresolved ambiguity* (as when the same term is used in different contexts with different meanings) and *unidentified redundancy* (as when different terms are used in different contexts with the same meanings).
- "How to *determine* the presence of ambiguity and redundancy in the first place? In other words, how can we assess the semantics of training data across different contexts?

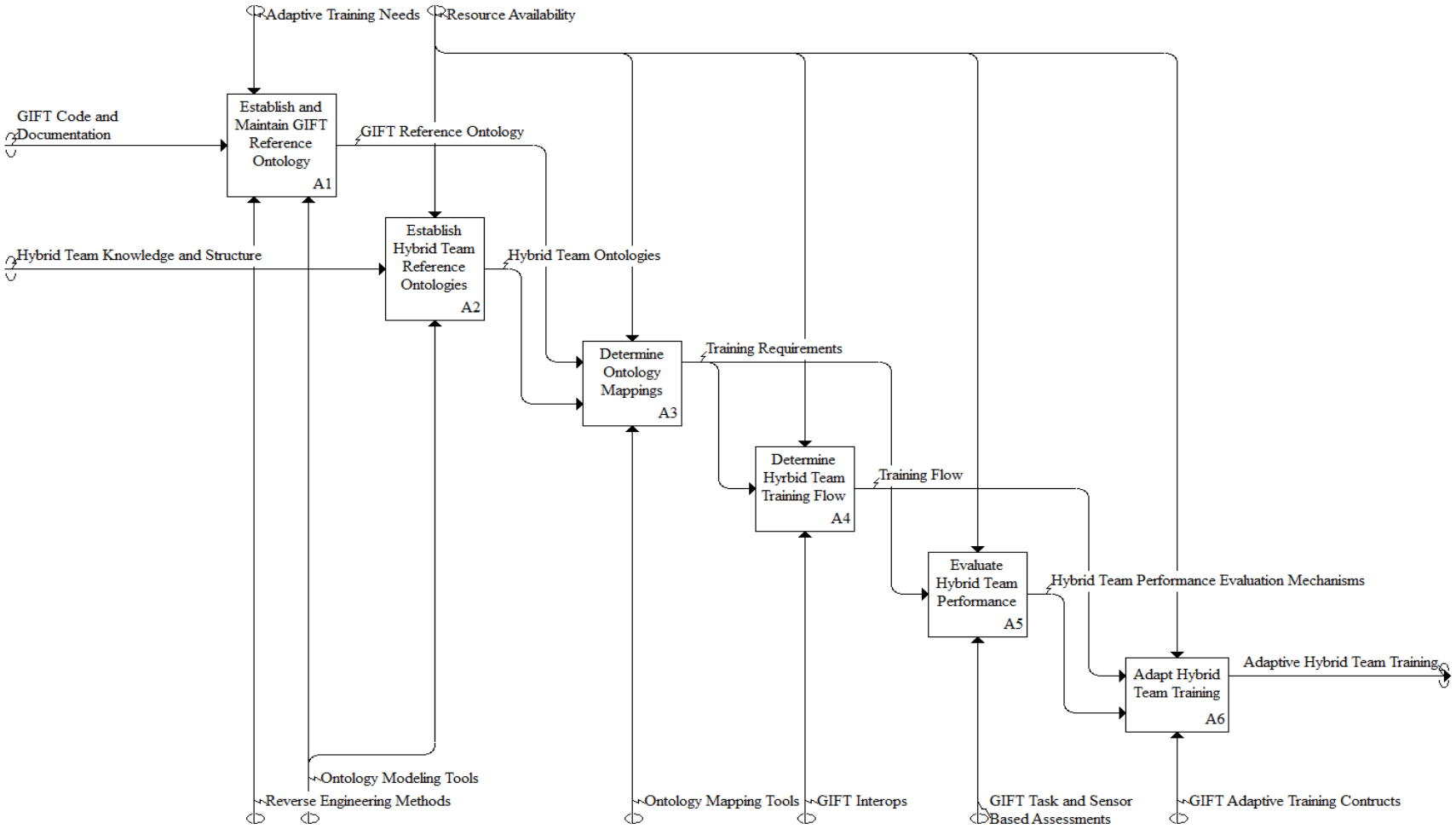
Solution

- Use ontologies to capture semantic rules of various team training contexts as well as GIFT
- Maintain a GIFT reference ontology
- Map team training ontologies to the GIFT reference ontology
- Use mapped ontologies to configure GIFT to support team training and performance evaluation

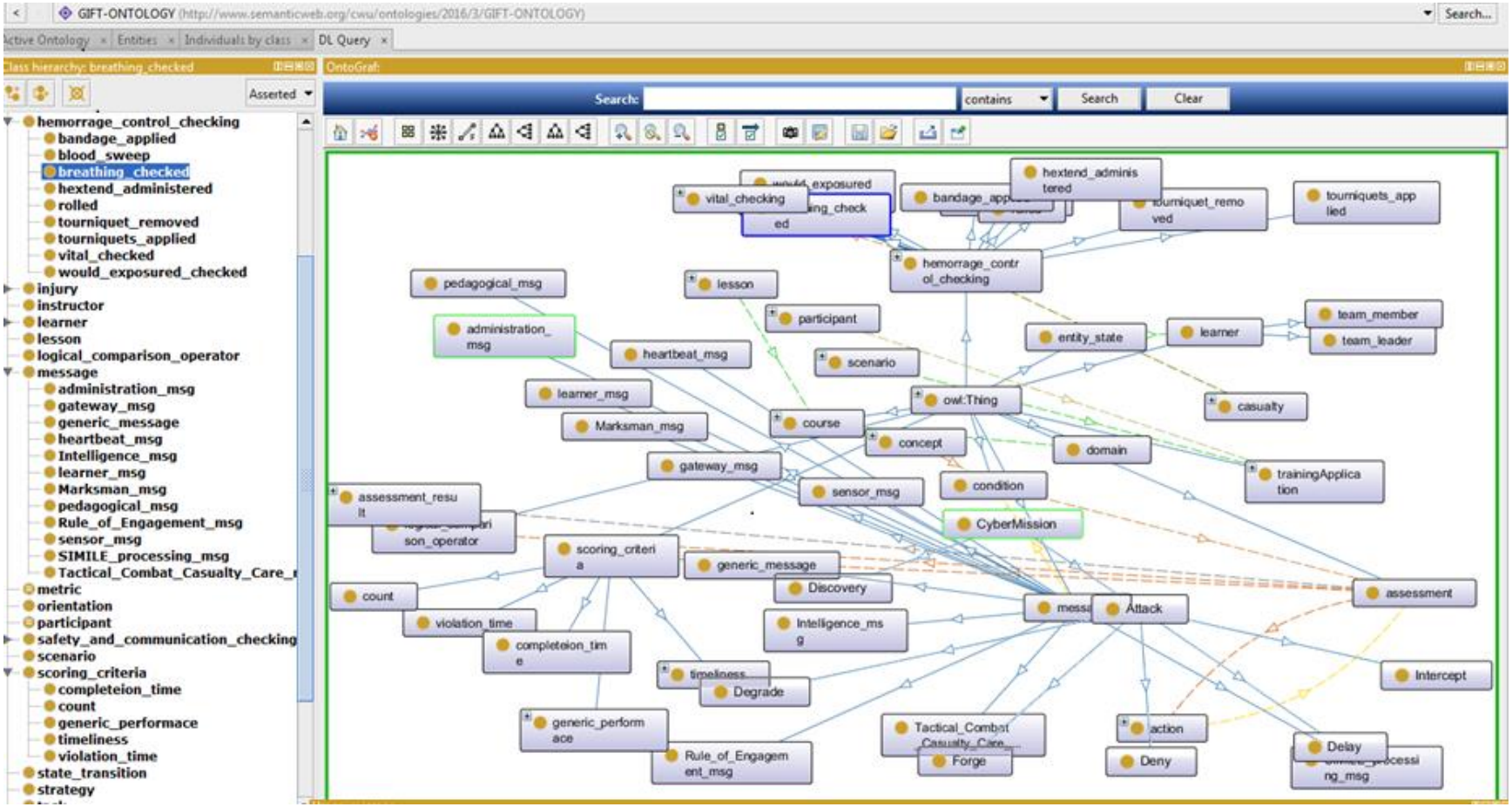
Assumptions

- GIFT is currently being / has been extended to support team training (e.g. Team DKF, Team Model, and Team Pedagogy)
- GIFT can simultaneously monitor and assess multiple user task-based data and sensor-based data
- Messages can be passed between learners and learning applications
  - Distributed teams and co-located teams

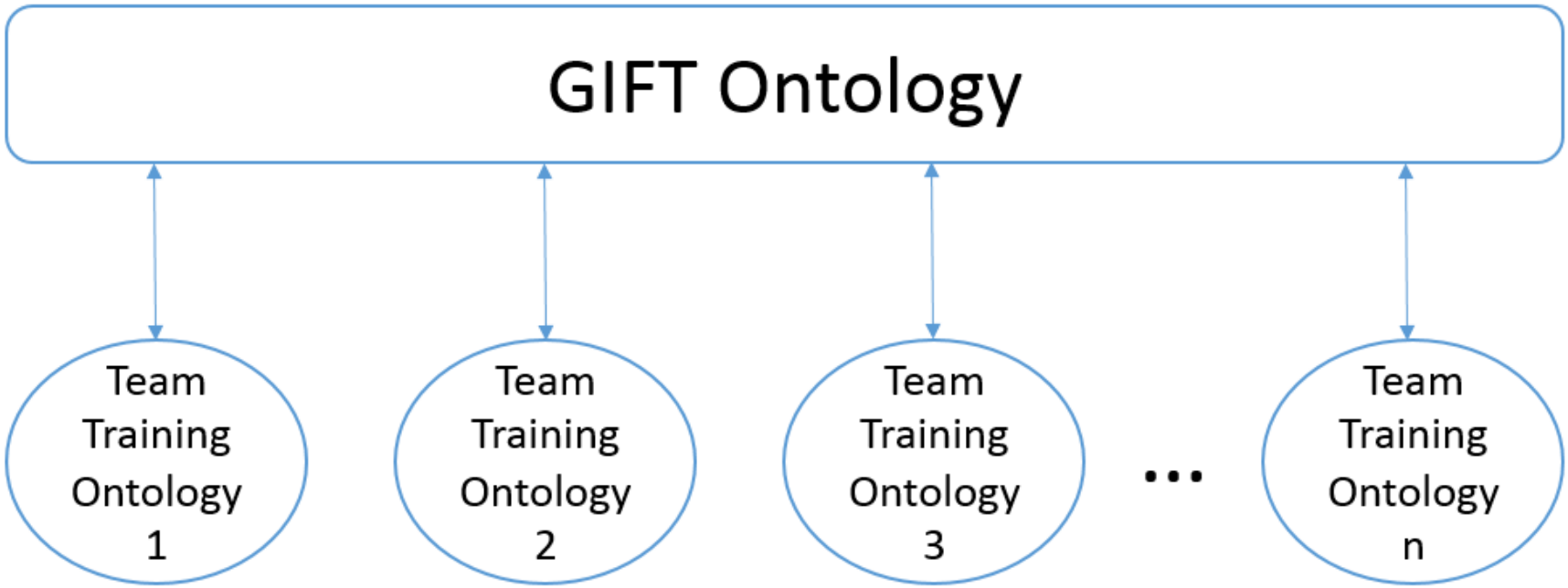
Method for Hybrid Team Training



GIFT Ontology Diagram

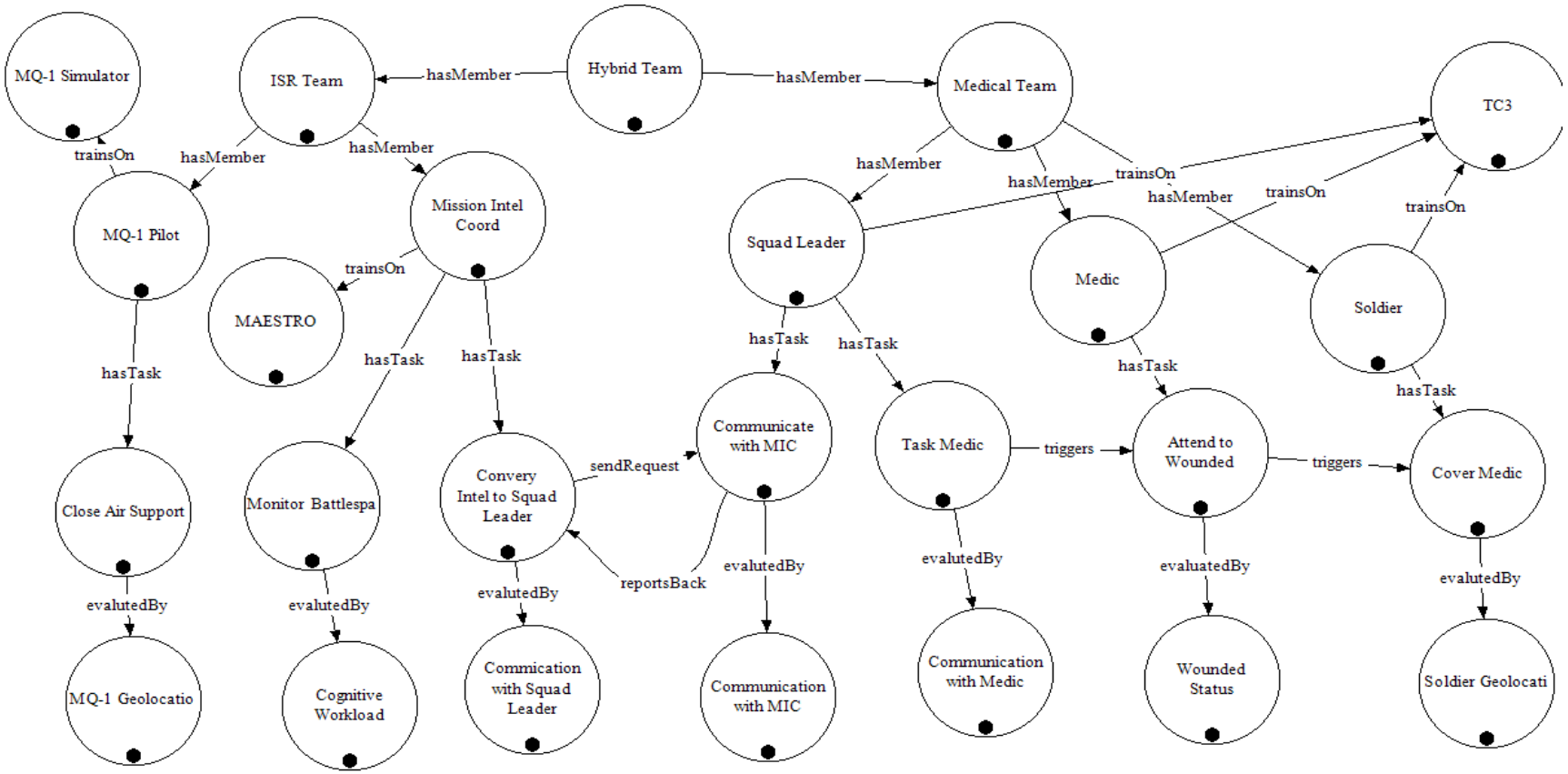


Ontology Mapping

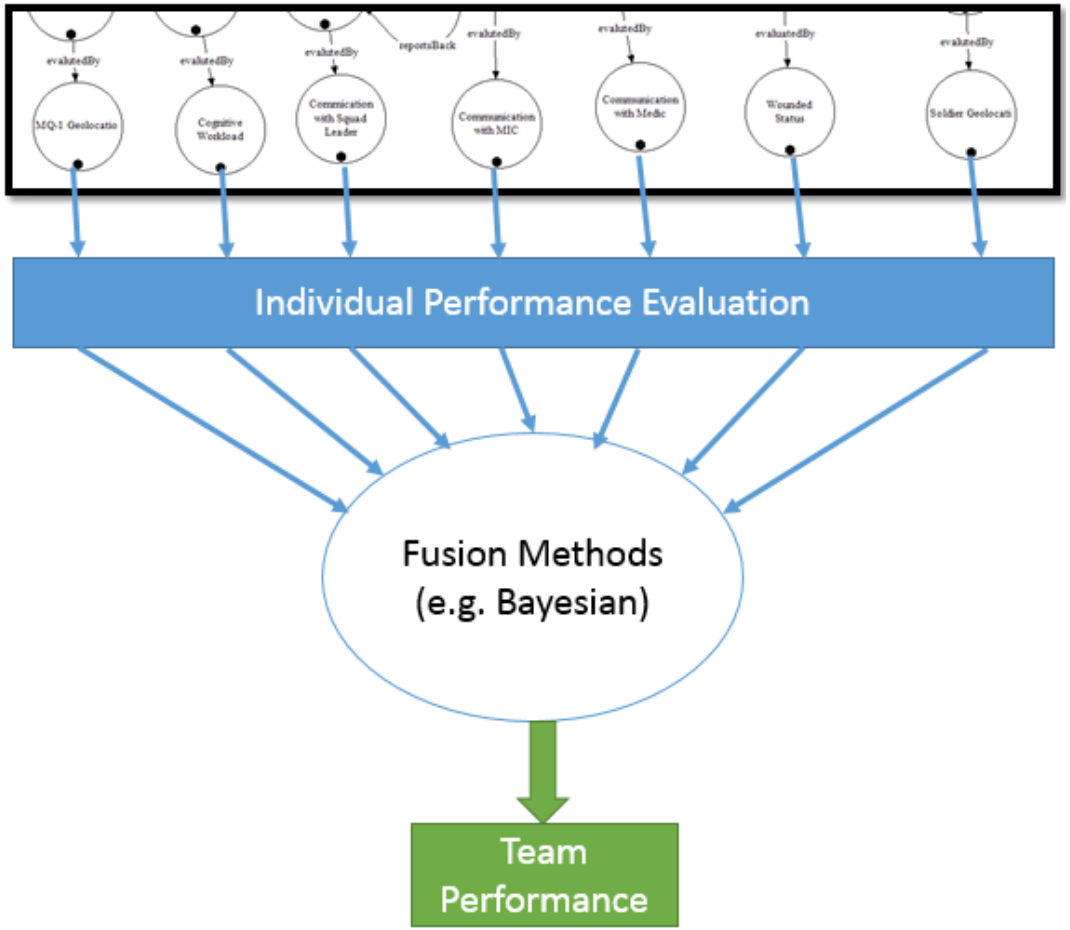


Example Hybrid Team Ontology

- Intelligence Domain interacting with Patrol Team



Team Performance Evaluation Approach



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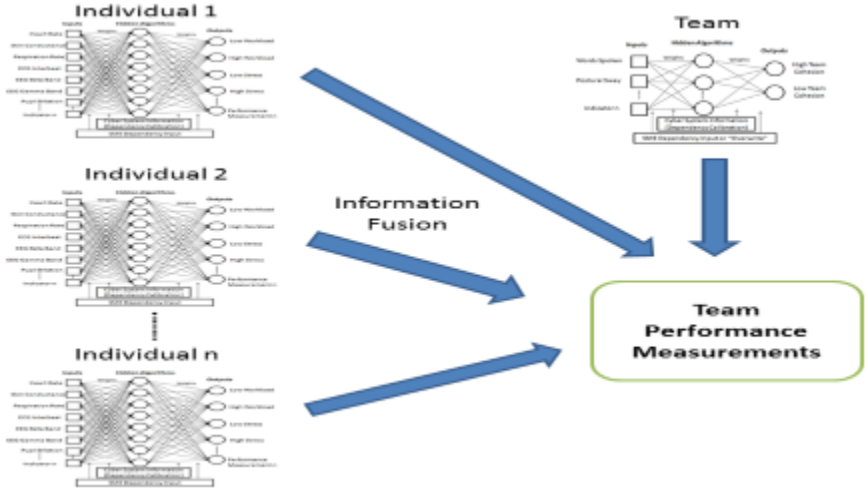
Sensor-Based Team Performance

- Metrics for ISR Team
  - Fatigue management
  - Attentiveness
  - Regulating stress level
- Metrics for Patrol Team
  - Nervousness
  - Alertness
  - Regulating stress level



Example Sensors

- EMOTIV Insight
  - Focus, Stress, Excitement, Relaxation, Interest, and Engagement

- Kinect v2
  - Eye Tracking, Movement Tracking, Heart Rate

- Empatica E4 Wristband
  - Skin Temperature, Galvanic Skin Response (Sweat), Motion, Blood Volume Pulse

Task-Based ISR Team Performance

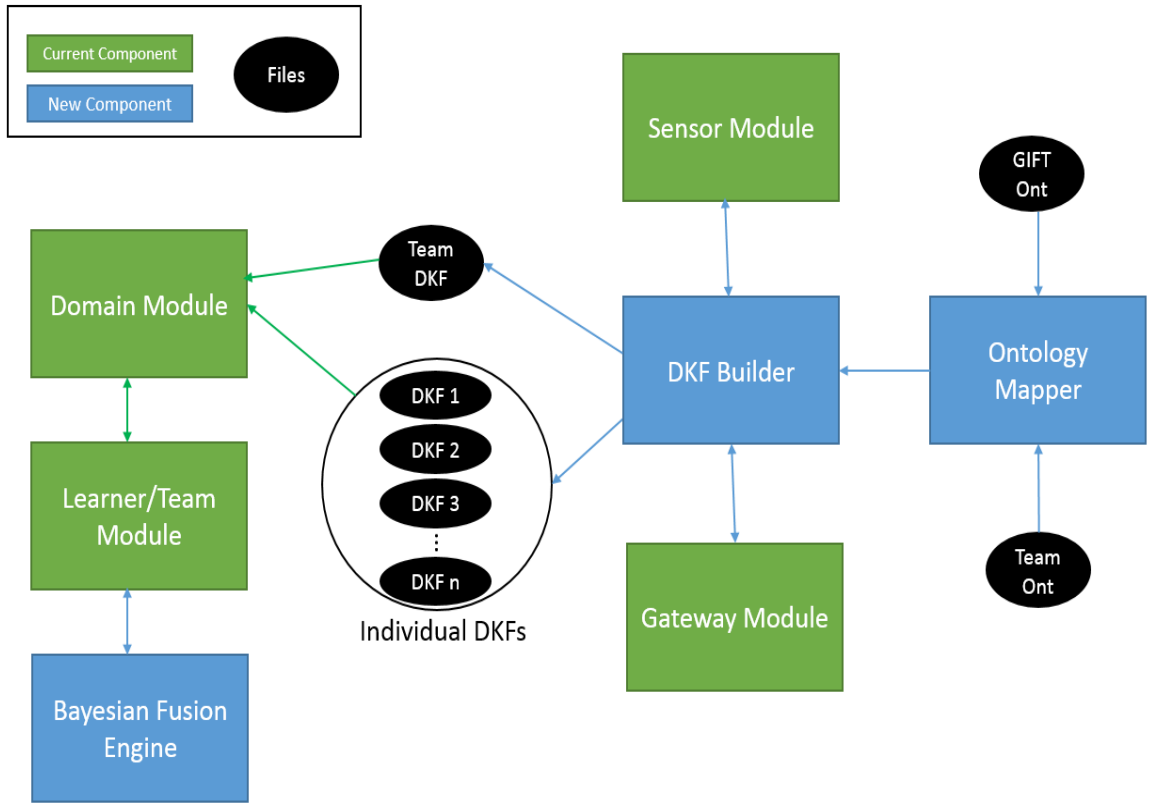
- Metrics for ISR Team Embedded in MAESTRO™
  a. Did MIC review the COP and send out follow up information on time?
  b. Did MIC send the message to the right person?
  c. Did MIC follow up with the person to whom he send the information?
  d. Did MIC use communication standards while relaying information?

Task-Based Patrol Team Performance

- Metrics for Patrol Team Embedded in TC3 SIM
  a. Was the criteria “stay close” violated?
  b. By what margin did team violate safe distance from building?
  c. Did medic stop bleeding and stabilize victim?
  d. Did MEDEVAC process get initiated at the right time?
  e. Did patrol team leader send acknowledge message to MIC after receiving recommendations?

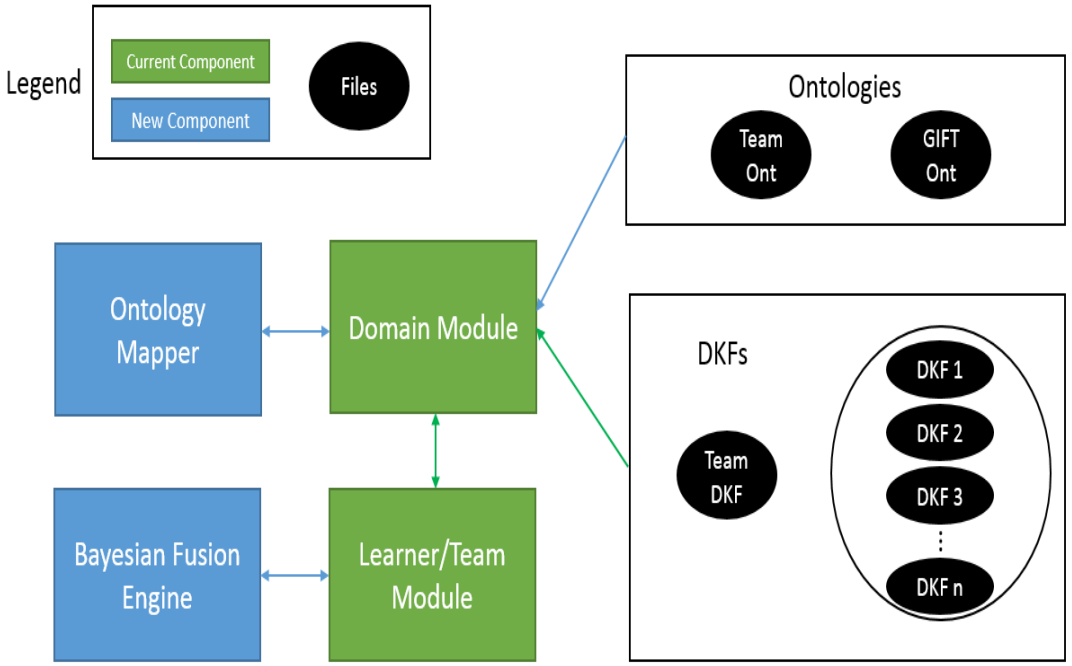
GIFT Architecture Extension – Option 1

- Incorporate External Ontology Mapper in GIFT
- Add External DFK Builder to GIFT
  - Build team and individual DKF files based on ontology
- Add Bayesian Fusion Engine to Learner/Team Module



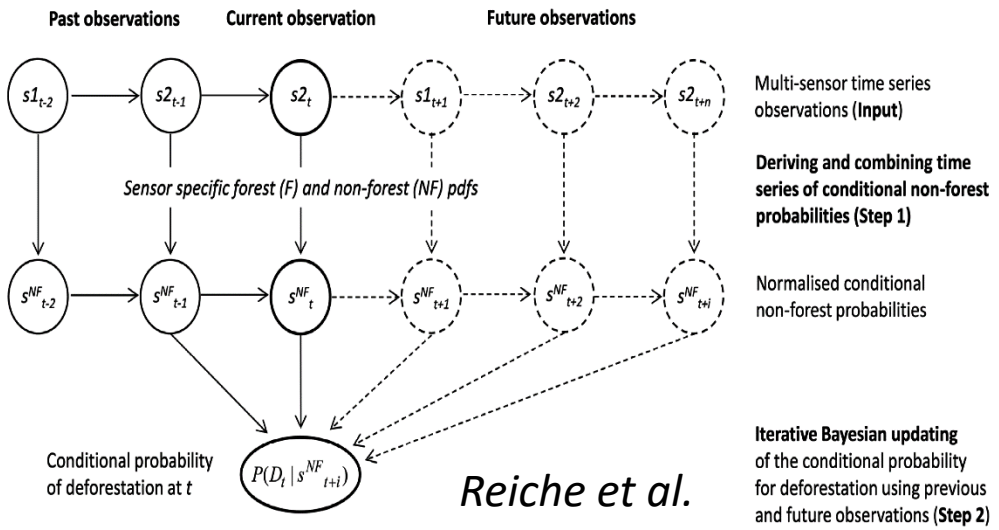
GIFT Architecture Extension – Option 2

- Integrate Ontology Mapper with Domain Module
- Domain Module can use DFK files OR Ontology files
- Domain Module uses Ontology Mapper when necessary
- Bayesian Fusion Engine added to Learner/Team Module



Why Bayesian Fusion?

- Reasonable estimates from little data
- "Simple" way to fuse individual performance metrics into team performance metrics
- Combine unlike data/information sets
  - Sensor data
  - Task data
- Customized fusion using weights
  - Domain Specific
- Real-time updating

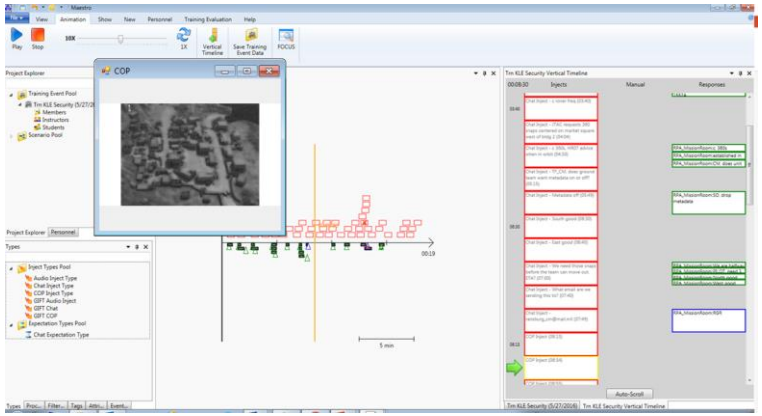


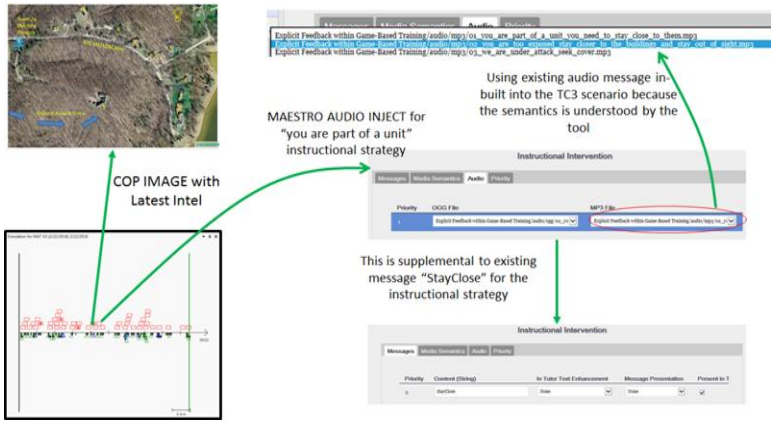
Using Bayesian Fusion in GIFT

- Fuse individual and team performance information
  - Sensor and task-based states
- Weights and performance states used to calculate team states
  - Team and Team of teams
- Weights defined based on training scenario
  - Possibly in DFK
  - Default weights also available

Example Multi-Domain Team Training

- TC3 Sim tool is leveraged for
  - Medic proving tactical field medical care
  - Patrol unit securing area
  - Patrol unit suppressing enemy fire
  - Squad leader coordinating MEDEVAC operations
- MAESTRO™ is leveraged for
  - MIC coordinating ISR information flow
  - MQ1 and A10 platforms coordinating CAS tasks
  - JTAC providing situational awareness to patrol team
  - GFC coordinating battlefield operations
- GIFT software is leveraged for
  - Authoring multi-domain team training course
  - Performance evaluation based on sensor outputs and evaluation measures





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Example Performance Evaluation Rules with TC3 Data

Audio Injects	TC3 Concepts	GIFT Evaluations	TC3 Metrics
Insurgents in the vicinity @ 00:12:15	"stay with unit"	Below Expectation	• away_from_unit (count > 3) • avg_time_outside_unit (violation time > 00:01:15)
Insurgents preparing for attack @ 00:15:30	"move under cover"	At Expectation	
Watch out BLDG 1, 5, 6, 7. Six hostiles identified @ 00:18:50	"return fire"	Below Expectation	• task_completed (completion time > 00:19:40)
Air support denied @ 00:19:40	"move to safe zone"	Below Expectation	• outside_safe_zone (violation time > 00:01:00)
All clear. No threats @ 00:21:15	"request CASEVAC"	At Expectation	

```
Rule "stay_with_unit_below_expectation"
{
    Concept( KeyName = "stay_with_unit" Transition = "below_expectation" Default = "unknown" )

    if( awayfromunit.count > 3 and avgtimeoutsideunit.violationtime > 00:01:15 )
    {
        Output( "stay_with_unit_below_expectation" )
    }
}
```

Scripted Rules used by SIMILE Engine

- Trainee responses are logged and evaluated to derive metrics as shown in last column
- "stay with unit"; "return fire"; and "move to safe zone" are found to be at below expectation grade
- Rules scripted in SIMILE workbench (*see box above*) to evaluate grades

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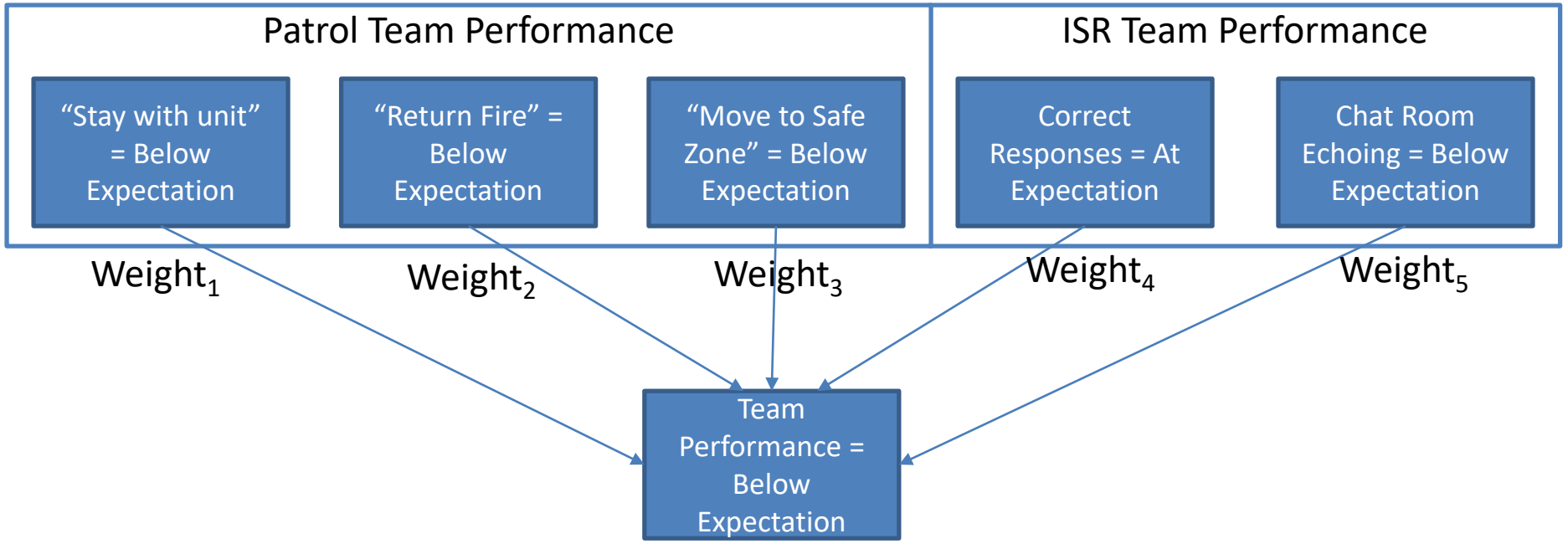
Evaluation Performance Evaluation Rules using MAESTRO™ Data

- MAESTRO™ compiles vital statistics like number of late response, echo in wrong chat room, incorrect response, response in wrong chat room, positive tag, and negative tag
- Evaluation scripts are written in SIMILE workbench to evaluate MAESTRO data and assign grades to trainees
- Example script for below expectation grade, If all these conditions are met:
  - Echo in Wrong Chat Room > 3;
  - Incorrect Response ≥ 2;
  - Late Response > 3;
  - Negative Tag > 2;
  - Positive Tag = 0
- Likewise, rules can be scripted for at expectation and above expectation grades

Evaluation of Team Data

- Bayesian Fusion Engine used to fuse team training results



Example Adaptation and Tutoring Rules

- Configured for each individual and team as a whole
  - Patrol Team
    - If("Stay with unit" == Below Expectation)
      - Provide tutoring feedback "You are too exposed, stay closer to buildings and stay out of sight."
  - ISR Team
    - If(Correct Responses == At Expectation)
      - Add new scenario thread
  - ISR and Patrol Team
    - If(Team Performance == Below Expectation
      - Reduce team scenario speed

Conclusions

- An ontology-driven method for hybrid adaptive team training.
- An enhanced Generalized Intelligent Framework for Tutoring (GIFT) architecture to support the hybrid adaptive team training method.
- A hybrid adaptive team training application example that shows the practical benefits of the method.

Future Work

- Methods for extending and generalizing the GIFT adaptive team training reference ontologies.
- Design and implementation of automated support for ontology analysis and harmonization to support training application integration.
- Design and implementation of inter-application information exchanges with GIFT for a broader range of training application areas.
- Design of mechanisms to mediate and exchange adaptive training content across multiple training modalities and types.

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Discussion and Questions