Interoperable Performance Assessment for Individuals and Teams Using Experience API

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INTRODUCTION

Organizations are making substantial investments in new training technology and methods of delivering training, such as mobile learning, virtual collaborative workspaces, and distributed simulations (ASTD, 2012). With industry focused on personalized and tailored learning, more adaptive training approaches for customizing training experiences are being developed. Adaptive training (also referred to as accelerated learning) is a generic term for a family of approaches that use individual difference variables to personalize the individual training experience by selecting an appropriate training event or changing the content within the event (Poeppelman, Blacksmith, & Yang, 2013).

Additionally, adaptive Intelligent Tutoring Systems (ITSs) or Computer-Based Tutoring Systems (CBTSs) provide a method of guiding self-development by managing real-time instructional decisions. These systems select ideal instructional strategies to meet the specific learning needs of individuals or teams (Sottilare, 2012). Where human tutors are either unavailable or impractical, ITSs provide opportunities for reflection, and change the content, direction, pace, and challenge level of instruction to optimize learning.

Currently, the United States Army is focusing on creating a more competitive environment for leaders and Soldiers through its new campaign for lifelong learning. To expand learning beyond the schoolhouse, the Army is evolving their goals to include new training methods and forms of performance tracking throughout ones career. The Army Learning Concept (ALC) 2015 (Department of the Army, 2011) is pushing the boundaries of research and practice and has introduced new architecture designs and concepts.

One recent effort at the Army Research Laboratory (ARL), Human Research and Engineering Directorate (HRED), Simulation and Training Technology Center (STTC) on Interoperable Performance Assessment (IPA) is presenting a path forward to greater efficiency of training performance across training systems. IPA, a method of uniformly defining and describing data about a user’s experience in a consistent way, has created a capability to enable different systems to leverage one another’s data to macro and micro adapt learner experiences. Specifically, the effort at ARL has developed an approach for enabling the Generalized Intelligent Framework for Tutoring (GIFT) to adapt learner’s future events or learning path based on past performance. This paper will highlight the current IPA efforts and provide an overview of the future research efforts surrounding IPA and GIFT.

EXPERIENCE API

Currently, the Department of Defense has a number of efforts underway related to tracking and assessing performance in order to enable these adaptive learner-centric environments. With known limitations of the Sharable Content Object Reference Model for environments like mobile, games, and simulations, the Advanced Distributed Learning (ADL) Initiative is currently working to extend the future support of interoperability of learning systems through a Training and Learning Architecture (Advanced Distributed

Learning, 2013). Specifically, ADL is focusing on new approaches to standards and frameworks, which include the Experience Application Programming Interface, or Experience API (xAPI).

The xAPI specification reached 1.0 as of April 26, 2013. This method defines an API to track data about learning experiences and defines a protocol for data structure and transmission by software components to communicate with one other (Advanced Distributed Learning, 2013). The xAPI defines a method to capture data about the interaction between a learner and a learning experience.

The xAPI allows tracking outside of a Learner Management System (LMS) to capture data about digital and non-digital learning and user experiences across the formal, informal, and experiential spectrum. This includes experiences from newer training environments, such as serious games, mobile applications, simulations, virtual world, and augmented reality.

The xAPI is based upon an open format specification for activity stream protocols, which are used to syndicate activities (Activity Streams, 2013). The xAPI specification defines a format using JavaScript Object Notation (JSON) to create statements that allow the capture of learning experiences. JSON is a text-based open standard designed for human-readable data interchange. The format of a statement is <Actor, Verb, Object> or “I did this.” **Error! Reference source not found.**1 below is an example of an xAPI statement in JSON.


```
{
  "id": "5d23f4c4-9368-46ad-8390-5a086f45a829",
  "actor": {
    "objectType": "Agent",
    "name": "Smith, Greg",
    "mbox": "mailto:admin@sp2.com"
  },
  "verb": {
    "display": {
      "en-US": "assessed"
    },
    "id": "http://www.SP2.com/assessed"
  },
  "object": {
    "objectType": "Agent",
    "name": "John Bates",
    "mbox": mailto:john.bates@us.army.mil
```


Figure 1. xAPI example statement

The xAPI specification is providing a means to uniformly describe data in meaningful way that has both flexibility and structure. As the ITS community continues to enable new methods of providing personalized feedback and instruction, xAPI will allow ITSs to share user data and enhance the capabilities of a system by leveraging data about performance outcomes and results.

INTEROPERABLE PERFORMANCE ASSESSMENT

The purpose of the current ARL research is to capture and leverage contextual performance measures from current systems and encode them into xAPI statements to tailor learning to the individual learner’s experience and level of proficiency on a concept or capability. Through the work performed, the concept of IPA was defined as “a method of uniformly defining and describing experience and context to assess learning and performance over time; to adapt training across a variety of environments, systems, and modalities, whereby performance is observed, assessed, evaluated, or asserted by systems or observers.”

Figure 2 shows a visualization of the IPA concept to represent a learner and how is tracked across multiple environments to adapt their pathway.

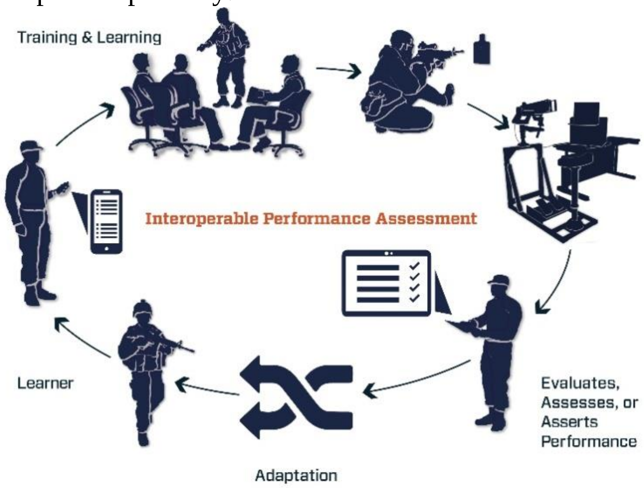

Figure 2. Interoperable performance assessment diagram

This definition not only combines the methods in which interoperable tracking occurs, but also (a) where the trainee, event, or training content is adapted and (b) how the data are collected. While the definition remains broad, the intent is to move toward a common understanding of what is meant by interoperable tracking of performance data and the goals of assessing performance over time.

The previous effort set out with the following objectives: (1) define best practices for defining and encoding performance measurement using xAPI statements; (2) develop a technical architecture for interoperable activity across current Army architectures; and, (3) build a proof-of-concept called the Soldier Performance Planner (SP^2). Below is an overview of each of the objectives and outcomes.

xAPI Encoding Best Practices Guide

The first research objective included the research of best practices for encoding individual performance data into xAPI statements from system-based (simulator) and observer-based (instructor) measures. Current efforts that capture individual and collective performance include an eXtensible Markup Language (XML) activity structure known as the Human Performance Measurement Language (HPML). This schema was designed to capture and assess performance across distributed simulations by a language that identifies critical fields and stores them within an XML activity structure. The major goal of HPML is to focus on bridging the gap between the software implementation of raw data to measurements and computing measurements into overall assessments. Overall, HPML is designed to allow the expression of important concepts from the training world so that others, such as training professionals, instructors, operators, and researchers, can use, aggregate, and understand the data easily (Stacy, Ayers, Freeman & Haimson, 2006). The current effort uses HPML constructs as a basis for describing current performance data that is being collected by various Army simulators, as well as to understand what type of system-based and observer-based data is being tracked across environments.

The result of reviewing HPML included a list of pre-defined constructs along with the associated definition, examples, and usage requirements. Examples of these constructs include: training objective, knowledge, skill, and roles. While some of the constructs were deemed useful as additional data sources or context, some are not required based on the current HPML schema.

The first objective resulted in the SP² Encoding Best Practices Guide that outlines data encoding considerations using the Experience API (xAPI) format to track data typically stored or described using HPML. The data formats used included xAPI version 1.0.1 and HPML version 3.1. The main purpose of the mapping was to provide guidance for encoding xAPI statements based upon consideration of the constructs of HPML.

Technical Architecture

The second research objective included developing requirements for ITSs, such as GIFT, to view this performance data. An xAPI statement is a human-readable set of data objects consisting of attribute-value pairs that use the JSON format. Data is sent in the form of time-stamped statements, which take on a natural language pattern of "subject-verb-object". Storage of these xAPI statements is done via a Learning Record Store (LRS) and allows access of that data by other systems. An LRS may be stand-alone or part of a larger system.

As described above, the key components of the technical architecture include (1) HPML, which captures raw data, measures, and computes assessments within systems; (2) xAPI, which can capture interoperable learning experience data at any level of granularity; (3) LRS, which enables centralized storage and retrieval of all learning data captured by the xAPI; and, (4) GIFT polling component, which allows the ITS to receive xAPI statements and make macro recommendations within GIFT. The GIFT polling component queries relevant statements for a learner from an LRS. Figure 3 shows the current SP² architecture diagram which contains all described components.

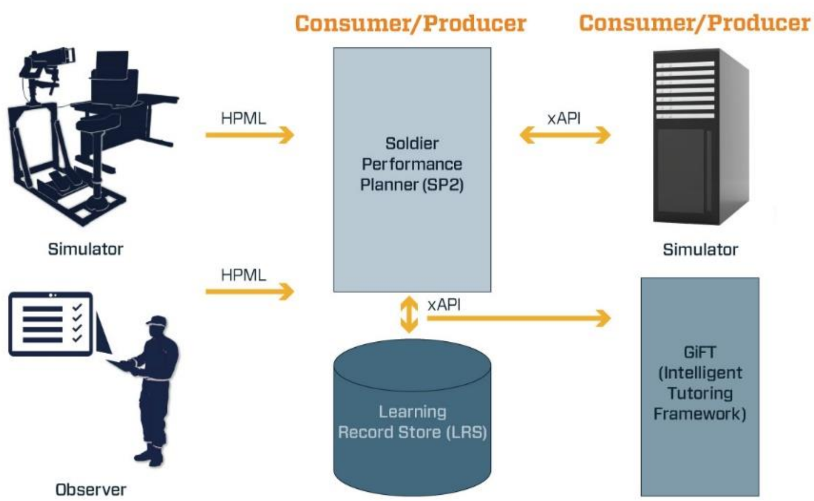

Figure 3. SP² architecture diagram

Soldier Performance Planner (SP²)

Lastly, the third project objective included the development of a prototype called the SP², which leverages the key elements found in the technical architecture above. Those include HPML, xAPI, LRS, and GIFT. The SP² HTML interface allows systems that use an LRS or HPML or xAPI data formats to connect and share data, add new individual data, and track individual and group performance data that will ultimately support adaptive and tailored learning across ITSs and other systems. While the data tracking functionality has traditionally been associated with the LMS, an LRS is able to collected statements that contain new types of training data that is being stored. The current purpose of xAPI and LRS is to support lifelong learning through persistence by tracking services and aggregating learner data from multiple systems. Figure 4 shows a screenshot of the SP² interface.

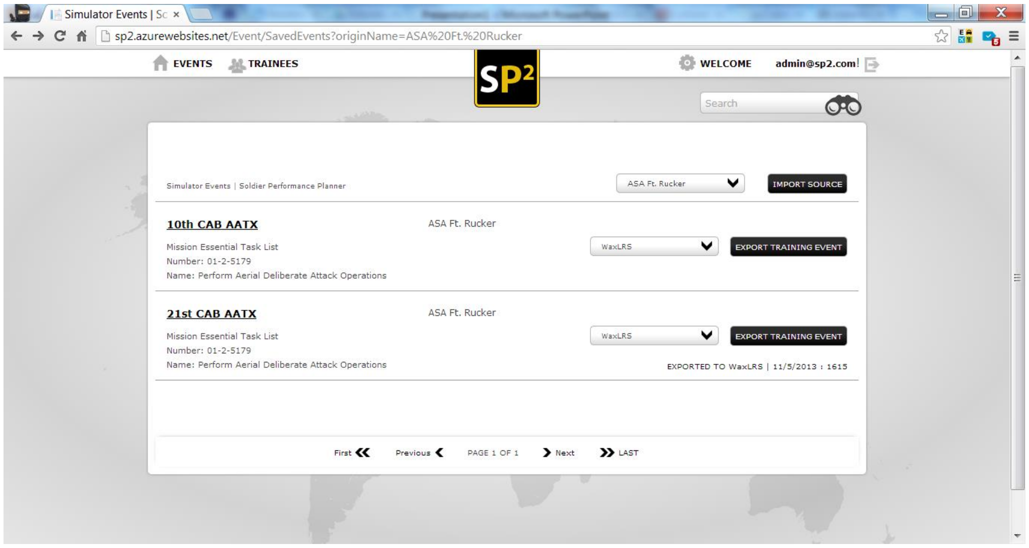

Figure 4. SP² interface

Generalized Intelligent Framework for Tutoring (GIFT)

Developed by ARL, GIFT is a modular tutoring system framework to support the instantiation of adaptive tutoring capabilities. It aims to research and prototype a computer-based tutoring framework to evaluate adaptive tutoring concepts, models, authoring capabilities, and instructional strategies (Sottilare, Goldberg, Brawner, Holden, 2012). The effort aims to do this across various populations, training tasks, and conditions, thus enabling summative and formative evaluations.

GIFT services provide authoring of CBTS components, tools and methods; management of instructional processes using best pedagogical practices based on the behaviors of expert human tutors; and, an assessment methodology to evaluate the effectiveness of CBTS and CBTS components, tools, and methods. GIFT provides services for learners, instructional system designers, expert behavior modelers, training system developers, trainers, and researchers. The infrastructure provides generic tutoring or remediation strategies to integrating systems based on learner performance.

The current research and use of xAPI within GIFT is meant to start by informing macro-adaptation methods. The GIFT polling component allows GIFT to communicate with the LRS, determine relevant adaptations, and macro-adapt recommendations for courses. The polling component adapts based upon xAPI statements that state whether the learner is at or above a level of proficiency for a competency or concepts indicate that a user is performing below a level proficiency for a competency or concept. Based on the current rule sets, courses are either no longer recommended or presented based on their past performance.

Additionally, current ARL efforts are developing a writing component that outputs data from GIFT into the xAPI format. This data mapping will enable outside LMSs and other systems to leverage xAPI statements describing user experiences that come from within GIFT. IPA efforts are looking at macro approaches to inform course recommendations and create more granular learner profiles that have intersystem data value.

COMMUNITY DEVELOPMENT

The purpose of xAPI and IPA is to describe, store, and provide access to learning experiences including traditional records, such as scores or completion status, as well as assertions of proficiency or deficiency for concepts, competencies, knowledge or skills. Intersystem communication between LMSs, ITSs, and other systems allows domain-independent ITSs and training technology-based solutions to aggregate rich and meaningful data across a continuum of systems to increase efficiency and effective use of learning and training assets. By understanding the current state and granular historical data of a learner, these systems will ultimately be able to adapt learner pathways at the macro and micro level. Figure 5 shows the data and functional ecosystem of the ITS, LRS, and xAPI.

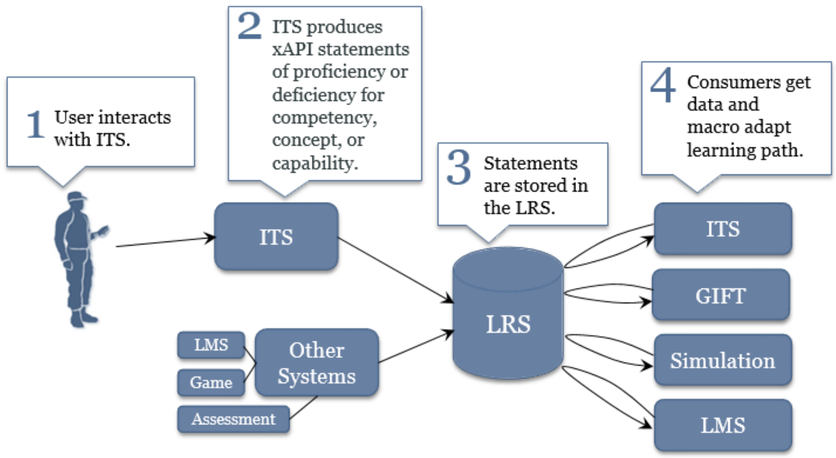

Figure 5. ITS, LRS and xAPI Ecosystem

Based on the current work to date surrounding SP² and the developed architecture, potential impacts to the design and development of GIFT might include the classification of additional data sets that inform GIFTs approach to intelligent tutoring. Additionally, outside simulators and systems including other ITSs might consider connecting to an LRS as an additional data store to support initialization of learner profiles, course selection within GIFT, and potential extraction of data from GIFT to modification of long-term learner profiles.

FUTURE RESEARCH

While current ITSs are focused on reducing high training development costs, improved standards, and adaptability to support tailored needs of the learner, there is still much research and development left to be done to attain this goal. As new domains continue to be explored, IPA best practices documentation and methods will iterate based on domain-specific verbs, actors, actor taxonomies, activities, and more domain specific context descriptions. Future IPA efforts should continue to explore tools and methods to convert these strategies into specific instructional tactics for implementation. For instance, statements from other systems about competencies, knowledge, and skills could be utilized to select teams, identify group scenarios, and determine individual mission injects that would leverage the strengths of the teams to mitigate team weaknesses.

The key to interoperability for performance assessment will also be to encode activity data across a number of streams (system-based measures, observer-based measures, computer-based training measures, physiological, etc.). To date, SP² has ingested system-based measures and observer-based measures for individuals and teams. Encoding of additional streams will allow more data types to be used for testing and validation. Current efforts are underway to determine what data sets are applicable and what systems will be used to demonstrate interoperability. The goal is to continue to introduce more data sources that will lead to a comprehensive approach, a validation technique to confirm the data encoding process, and additional data sources to inform the community of encoding best practices across relevant domains.

Current community driven efforts are being leveraged to support this encoding effort. A number of current projects from ARL and other Services are working toward a common end. An emergence of adoption of usage and tools is happening around the Experience API specification, which has the ability to accelerate the ALC 2015 goals. Key support tools and practices are being developed to share methods of tracking performance data to enable tailored and adaptive learning across current ITSs, such as GIFT.

Based on the community and data encoding efforts, enhancements should continue to be made to GIFT so that additional macro and micro approaches are evolved into the GIFT architecture. Additionally, other adaptive engines that leverage xAPI should also be leveraged for experimentation purposes. Furthermore, much of the future is focused on systems that provide adaptive and tailored learning not only for individuals but also teams. Leveraging encoded xAPI individual and team performance data from multiple systems still poses a unique set of challenges that need to be explored further. Focus remains on having a highly agile system that is capable of tracking performance, experiences, and group data, as well as individual levels of data, from the national and Joint levels.

Finally, research needs to continue to focus on the intersection between the variety of efforts underway at the DoD as they relate to tracking and assessing performance, which is an important step to enable these adaptive learner-centric environments. The current work recently completed at ARL presents an opportunity to conduct further analyses and technical exchanges among groups in order to make the community intersection possible around adaptive learning systems. These integration efforts will continue to grow with specifications such as Experience API in order to enable 21st century technologies to adapt based on learner profiles and performance data.

REFERENCES

Activity Streams Project. (2013). Activity Streams Home Page. Available at http://activitystrea.ms.

Advanced Distributed Learning. (2013). *ADL Learning Record Store*. Retrieved 2013, from www.adlnet.gov: https://lrs.adlnet.gov/xapi/

Advanced Distributed Learning. (2013). *Sharable Content Object Reference Model*. Retrieved May 2013, from http://www.adlnet.gov/overview

Advanced Distributed Learning. (2013). *Training and Learning Architecture (TLA)*. Retrieved from Advanced Distributed Learning: http://www.adlnet.gov/capabilities/tla

Advanced Distributed Learning. (2013). *Training and Learning Architecture (TLA): Experience API (xAPI)*. Retrieved from http://www.adlnet.gov/tla/experience-api

Advanced Distributed Learning. (2013). *xAPI Specification*. Retrieved 2013, from Github: https://github.com/adlnet/xAPI-Spec

ASTD. (2012). *2012 State of the Industry Report.* Alexandria: ASTD Press.

Department of the Army. (2011). *The U.S. Army Learning Concepts for 2015.* Washington: Department of Defense.

Poeppelman, T. R., Blacksmith, N. & Yang, Y. (2013, Oct.). Application of modern technology and social media in the workplace. *The Industrial-Organizational Psychologist*, *51*(2), 119-126.

Sottilare, R. A. (2012). Considerations in the Development of an Ontology for a Generalized Intelligent Framework for Tutoring. In Proceedings of the *International Defense and Homeland Security Simulation Workshop 2012*, Vienna, Austria.

Sottilare, R.A., Brawner, K.W., Goldberg, B.S., & Holden, H.K. (2012) *The Generalized Intelligent Framework for Tutoring (GIFT)*. Orlando, FL: U.S. Army Research Laboratory – Human Research & Engineering Directorate (ARL-HRED).

Stacy, W., Ayers, J., Freeman, J., & Haimson, C. (2006). Representing Human Performance with Human Performance Measurement Language. Washington, DC. Aptima, Inc.