Society Briefs

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IEEE 1849™: The XES Standard

The Second IEEE Standard Sponsored by IEEE Computational Intelligence Society

IEEE Computational Intelligence Society (CIS) has entered the world of the IEEE standardization by sponsoring the IEEE 1855™ project, in which a well-defined language for the representation of fuzzy systems has been defined[1]. The IEEE 1855™ is the first IEEE standard technology sponsored by IEEE CIS, established as a result of the activities accomplished by the IEEE 1855™ standardization group, led by Giovanni Acampora (Chair), Bruno Di Stefano (Vice Chair) and Autilia Vitiello (Secretary). Building on the success of IEEE 1855™, other proposals for the sponsorship of IEEE standardization have been submitted to the IEEE CIS Standards Committee. Particularly in 2013, the IEEE CIS Technical Committee on Data Mining presented a proposal for starting a new standardization process related to the *eXtensible Event Stream* (XES) technology, a unified language for modelling event data in the field of process mining. The IEEE CIS Standards Committee, after having evaluated the proposal, has filed a motion to the IEEE CIS AdCom to request IEEE CIS to act as a sponsor for a new standardization process for XES. The motion was approved by the IEEE CIS AdCom in 2014 in Beijing, China. Successively, the proposal has been moved to the IEEE Standards Association, which has opened the project IEEE P1849 and requested Wil van der Aalst and Eric Verbeek to create a working group aimed at releasing the standard IEEE 1849™, the second IEEE standard technology sponsored by IEEE CIS.

Why do we need the XES Standard?

The goal of the *eXtensible Event Stream* (XES) Standard is to standardize a language to transport, store, and exchange (possibly large volumes of) event data (e.g., for process mining).

The spectacular growth of the digital universe, summarized by the overhyped term "Big Data," makes it possible to record, derive, and analyze events. Events may take place inside a machine (e.g., an X-ray machine, an ATM, or baggage handling system), inside an enterprise information system (e.g., an order placed by a customer or the submission of a tax declaration), inside a hospital (e.g., the analysis of a blood sample), inside a social network (e.g., exchanging e-mails or twitter messages), inside a transportation system (e.g., checking in, buying a ticket, or passing through a toll booth), etc. Events may be "life events," "machine events," or "organization events." The term Internet of Events (IoE),[2] refers to all event data available. The IoE is composed of:

- The Internet of Content (IoC): all information created by humans to increase knowledge on particular subjects. The IoC includes traditional web pages, articles, encyclopedia like Wikipedia, YouTube, e-books, newsfeeds, etc.
- The Internet of People (IoP): all data related to social interaction. The IoP includes e-mail, Facebook, Twitter, forums, LinkedIn, etc.
- The Internet of Things (IoT): all physical objects connected to the network. The IoT includes all things that have a unique id and a presence in an Internet-like structure.
- The Internet of Locations (IoL): refers to all data that have a geographical or geospatial dimension. With the uptake of mobile devices (e.g. smartphones), more and more

[1] "IEEE Standard for Fuzzy Markup Language," in *IEEE Std 1855–2016*, vol., no., pp.1–89, May 27 2016, doi: 10.1109/IEEESTD.2016.7479441.

[2] W.M.P. van der Aalst. Data Scientist: The Engineer of the Future. In K. Mertins, F. Benaben, R. Poler, and J. Bourrieres, editors, *Proceedings of the I-ESA Conference*, volume 7 of *Enterprise Interoperability*, pages 3–28. Springer, Berlin, 2014.

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events have location or movement attributes.

Note that the IoC, the IoP, the IoT, and the IoL are overlapping. For example, a place name on a webpage or the location from which a tweet was sent. Process mining aims to exploit event data in a meaningful way, for example, to provide insights, identify bottlenecks, anticipate problems, record policy violations, recommend countermeasures, and streamline processes. This explains our focus on event data.

Process mining is an emerging discipline providing comprehensive sets of tools to provide fact-based insights and to support process improvements. This new discipline builds on process model-driven approaches and data mining. Process mining provides a generic collection of techniques to turn event data into valuable insights, improvement ideas, predictions, and recommendations. The starting point for any process mining effort is a collection of events commonly referred to as an event log (although events can also be stored in a database and may be only available as an event stream). A wide range of process mining techniques is available to extract value and actionable information from event data. Process discovery techniques take an event log or event stream as input and produce a process model without using any a-priori information. Conformance checking can be used to check if reality, reflected by the event data, conforms to a predefined process model and vice versa. Process mining can also be used to extend process models with performance-related information, e.g., bottlenecks, waste, and costs. It is event possible to predict problems and suggest actions.

Currently, there are over 25 commercial process mining tools. In fact, the adoption of process mining has been accelerating in recent years. Currently, there are about 25 software vendors offering process mining tools. Tools like Disco (Fluxicon), Celonis Process Mining, ProcessGold Enterprise Platform, Minit, myInvenio, Signavio Process Intelligence, QPR ProcessAnalyzer, LANA Process Mining, Rialto Process, Icris Process Mining Factory, Worksoft Analyze & Process Mining for SAP, SNP Business Process Analysis, webMethods Process Performance Manager, and Perceptive Process Mining are now available. Moreover, open source tools like ProM, ProM Lite, and RapidProM are widely used. It is vital that event data can be exchanged between these tools. Several of these tools already support XES. For example, it is easy to exchange XES data between Disco, Celonis, ProM, Rialto Process, minit, and SNP.

History of the XES Standardization

For this transfer and storage, the IEEE Task Force on Process Mining in its meeting at the BPM 2010 conference on September 15th, 2010, initiated the IEEE standardization process for the *Extensible Event Stream* standard, or XES in short. To guide this process, in September 2012 an initial small XES Working Group (XES WG) was formed, which reached agreement on the XES Standard in 2013. On July 13th, 2014, the IEEE Computational Intelligence Society (IEEE CIS) accepted sponsorship for the XES Standard. The sponsor submitted the Project Approval Request (PAR) to the IEEE Standards Association (IEEE SA), which accepted the PAR on March 26th, 2015. On August 22nd, 2015 the XES Working Group was extended, and submitted the first external version for the XES Standard to the IEEE SA for Mandatory Editorial Coordination on December 2nd, 2015. Some minor changes were made as a result of this coordination, and the second external version went into ballot on February 16th, 2016. This ballot ended on March 18th, 2016, with a 95% response rate, one abstention, and a 100% approval rate. As a result of the comments received during the ballot, the XES WG agreed not to allow for local timestamps in the XES Standard but to require proper UTC timestamps instead. As this change was not considered to be an editorial change, a recirculation of the third external version was required, which was initiated on June 27th, 2016. In this recirculation, no votes were changed, and no more comments were received. As a result, this third external version of the XES Standard was submitted on July 19th, 2016 to the IEEE SA Revision Committee (RevCom). During its meeting on September 19th, 2016, RevCom recommended this version of the XES Standard to be approved. During its meeting on September 22nd, 2016, IEEE SA accepted this recommendation and approved the third external version of the XES Standard. After a short editorial process, the final version of the XES Standard was published by IEEE SA on November 11th, 2016.

The published XES Standard can be found in the IEEE Digital Library (through the URL http://ieeexplore.ieee.org/document/7740858/), and can be referred to use the DOI 10.1109/IEEESTD.2016.7740858.

A brief glimpse into the XES Standard

Figure 1 shows the XML serialization for the XES Standard as a state machine flow diagram. The main part of the diagram is the part containing the *log*, the *traces* (a trace bundles all events related to some case), the *events*, and the *attributes*. As the diagram shows, all these elements may have any number of attributes, and an attribute can be of seven different types (six simple types and one list type).

A *classifier* assigns to each event an identity, which makes it comparable to others (via their assigned identity). Examples of such identities include the descriptive name of the activity the event relates to, the descriptive name of the case the event relates to, the descriptive name of the cause of the event, and the descriptive name of the resource the event relates to.

An *extension* defines a (possibly empty) set of attributes for every type of element. The extension provides points of reference for interpreting these attributes, and, thus, for their containing elements. Extensions therefore are primarily a vehicle for attaching semantics to a set of defined attributes per element. Extensions have many possible uses. One important use is to introduce a set of commonly understood attributes

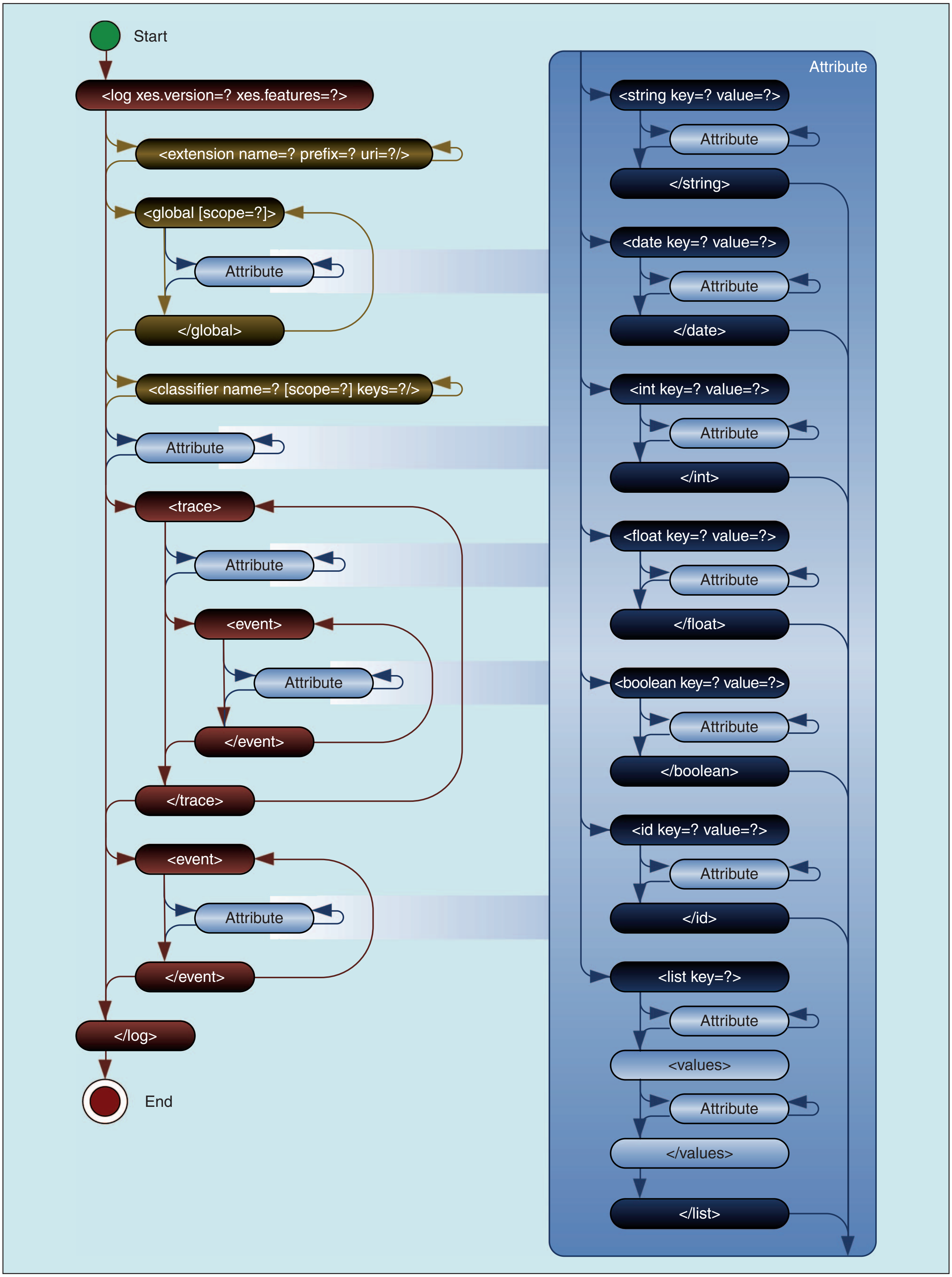

FIGURE 1 State machine flow diagram for the XES XML serialization.

which are vital for a specific perspective or dimension of event log analysis (and which may even not have been foreseen at the time of developing this Standard). As an example, the Concept extension stores a generally understood name for any element. For logs, the name attribute may store the name of the process having been executed. For traces, the name attribute usually stores the case ID. For events, the name attribute represents the name of the executed activity represented by the event. Other uses of extensions include the definition of generally-understood attributes for a specific application domain (for example, medical attributes for hospital processes), or for supporting special features or requirements of a specific application.

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Scope

This standard defines World Wide Web Consortium (W3C) Extensible Markup Language (XML) structure and constraints on the contents of XML 1.1 documents that can be used to represent extensible event stream (XES) instances. An XES instance corresponds to a file-based event log or a formatted event stream that can be used to transfer event-driven data in a unified and extensible manner from a first site to a second site. Typically, the first site will be the site generating this event-driven data (for example, workflow systems, case handling systems, procurement systems, devices like wafer steppers and X-ray machines, and hospitals) while the second site will be the site analyzing this data (for example, by data scientists and/or advanced software systems).

To transfer event-driven data in a unified manner, this standard includes a W3C XML Schema describing the structure of an XES instance. To transfer this data in an extensible manner, this standard also includes a W3C XML Schema describing the structure of an extension to such an XES instance. Basically, such an extension provides semantics to the structure as prescribed by the XES instance. Finally, this standard includes a basic collection of such extensions.

Purpose

The purpose of this standard is to provide a generally acknowledged XML format for the interchange of event data between information systems in many applications domains on the one hand and analysis tools for such data on the other hand. As such, this standard aims to fix the syntax and the semantics of the event data which, for example, is being transferred from the site generating this data to the site analyzing this data. As a result of this standard, if the event data is transferred using the syntax as described by this standard, its semantics will be well understood and clear at both sites.

Conclusions

IEEE 1849™ represents another important milestone in the field of standardization activities sponsored by IEEE CIS. With IEEE 1855™ computational intelligence researchers have been provided with a unified approach to model fuzzy systems in a simple, fast and interoperable way. At the same way,

FIGURE 2 Wil van der Aalst, Chair of IEEE 1849 WG, Chair of IEEE Task Force on Process Mining, Eindhoven University of Technology, The Netherlands.

FIGURE 3 Christian Günther, Vice-Chair of IEEE 1849 WG, Fluxicon, The Netherlands.

FIGURE 4 Eric Verbeek, Secretary of IEEE 1849 WG, Member of IEEE CIS Standards Committee, Eindhoven University of Technology, The Netherlands.

IEEE 1849™ will represent a solid and unified technology aimed at strongly improving the performance of scientists and engineers working in the area of business intelligence, process mining and so on. In this scenario, the role of the IEEE CIS Standards Committee will be always to constantly monitor the development of new computational intelligence technologies, which are ready to become an IEEE standard and support the activity of researchers acting in the wonderful realm of computational intelligence in concretizing their ideas.

Janusz Kacprzyk
IEEE CIS 2016 Awards Committee Chair, Systems Research Institute, Polish Academy of Sciences Warsaw, POLAND

2017 IEEE CIS Awards

Fuzzy Systems Pioneer Award
Chin-Teng Lin, University of Technology Sydney, AUSTRALIA
For contributions in developing fuzzy neural networks with various learning abilities and their real-world applications.

Dr. Chin-Teng Lin received the B.S. degree from National Chiao-Tung University (NCTU), Taiwan in 1986, and the Master and Ph.D. degree in electrical engineering from Purdue University, USA in 1989 and 1992, respectively. He is currently the Distinguished Professor of Faculty of Engineering and Information Technology, University of Technology Sydney, and Lifelong Chair Professorship of NCTU. Dr. Lin also owns International Faculty of University of California at San-Diego (UCSD), and Honorary Professorship of University of Nottingham. Dr. Lin was elevated to be an IEEE Fellow for his contributions to biologically inspired information systems in 2005, and was elevated to International Fuzzy Systems Association (IFSA) Fellow in 2012. Dr. Lin received the IEEE Fuzzy Systems Pioneer Award in 2017, Outstanding Achievement Award by Asia Pacific Neural Network Assembly in 2013, Outstanding Electrical and Computer Engineer, Purdue University in 2011, and Merit National Science Council Research Fellow Award, Taiwan in 2009. He served as the Editor-in-chief of IEEE Transactions on Fuzzy Systems in 2011-2016. He also served on the Board of Governors at IEEE Circuits and Systems (CAS) Society in 2005–2008, IEEE Systems, Man, Cybernetics (SMC) Society in 2003–2005, IEEE Computational Intelligence Society (CIS) in 2008–2010, and Chair of IEEE Taipei Section in 2009–2010. Dr. Lin is the Distinguished Lecturer of IEEE CAS Society in 2003–2005, and CIS Society in 2015–2017. He served as the Deputy Editor-in-Chief of IEEE Transactions on Circuits and Systems-II in 2006–2008. Dr. Lin was the Program Chair of IEEE International Conference on Systems, Man, and Cybernetics in 2005 and General Chair of 2011 IEEE International Conference on Fuzzy Systems. Dr. Lin is the coauthor of Neural Fuzzy Systems (Prentice-Hall), and the author of Neural Fuzzy Control Systems with Structure and Parameter Learning (World Scientific). He has published more than 200 journal papers and 80 patents (H-index: 56) in the areas of computational intelligence, fuzzy neural networks, natural cognition, brain-computer interface, intelligent systems, multimedia information processing, machine learning, robotics, and intelligent sensing and control, including approximately 110 IEEE journal papers.

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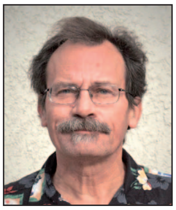
Evolutionary Computation Pioneer Award
Kenneth V. Price, USA
For the initial development and research on differential evolution.



Kenneth V. Price earned his B.Sc. in physics from Rensselaer Polytechnic Institute in 1974. He briefly worked as a supervisor at the Teledyne-Gurley Scientific Instrument Company in Troy, New York before moving to San Francisco. He currently resides in Vacaville, California. An avid hobbyist, he is self-taught in the field of evolutionary computation. In 1994, he published an early ensemble annealing, threshold accepting algorithm ("genetic annealing"), which led Dr. R. Storn to challenge him to solve the Tchebyshev polynomial fitting problem. Ken's discovery of *differential mutation* proved to be the key to solving not only the Tchebyshev polynomial fitting problem, but also many other difficult numerical global optimization problems. He is co-author of both the seminal paper on the differential evolution algorithm and the book "Differential Evolution: A practical approach to global optimization." Ken has authored or coauthored 7 additional