

# Election Markup Language (EML) Specification Version 6.0

# **Committee Specification 01**

# 19 August 2010

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#### **Technical Committee:**

OASIS Election and Voter Services TC

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#### **Related work:**

This specification supercedes:

• Election Markup Language (EML) v5.0

#### See also:

- EML Data Dictionary
- EML Schemas
- EML Core Components

#### **Declared XML Namespace:**

urn:oasis:names:tc:evs:schema:eml

#### **Abstract:**

This document describes the background and purpose of the Election Markup Language, the electoral processes from which it derives its structure and the security and audit mechanisms it is designed to support. It also provides an explanation of the core schemas used throughout, definitions of the simple and complex datatypes, plus the EML schemas themselves. It also

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covers the conventions used in the specification and the use of namespaces, as well as the quidance on the constraints, extendibility, and splitting of messages.

#### Status:

This document was last revised or approved by the Election and Voter Services Technical Committee on the dates shown in Appendix C – Revision History. The level of approval is also listed above. Check the "Latest Version" or "Latest Approved Version" location noted above for possible later revisions of this document.

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# 1. Executive Summary

- 2 OASIS, the XML interoperability consortium, formed the Election and Voter Services Technical
- 3 Committee in the spring of 2001 to develop standards for election and voter services information using
- 4 XML. The committee's mission statement is, in part, to:
- 5 "Develop a standard for the structured interchange among hardware, software, and service providers who
- 6 engage in any aspect of providing election or voter services to public or private organizations..."
- 7 The original objective in 2001 was to introduce a uniform and reliable way to allow systems involved in
- 8 the election process to interact. The overall focus today provides a rich standard that is:
- Multinational: Our focus is to have standards that can be adopted globally.
- **Flexible**: Effective across the different voting regimes (e.g. proportional representation or 'first past the post') and voting channels (e.g. Internet, SMS, postal or traditional paper ballot).
- Multilingual: Flexible enough to accommodate the various languages and dialects and vocabularies.
- Adaptable: Resilient enough to support elections in both the private and public sectors.
- **Secure:** Able to secure the relevant data and interfaces from any attempt at corruption, as appropriate to the different requirements of varying election rules.
- **Technology agnostic:** technologically stable and forward deployable with backward feature compatibility
- 18 The primary deliverable of the committee is the Election Markup Language (EML). This is a set of data
- and message definitions described as XML schemas along with a dictionary of core terms and structures
- 20 that enable predictable and consistent foundation mechanisms. The messages that form EML are
- intended for transfer between systems. It is not intended that all aspects of an election system will have a corresponding schema.
- 23 At present EML includes specifications for:
- Candidate Nomination, Response to Nomination and Approved Candidate Lists
- Referendum Options Nomination, Response to Nomination and Approved Options Lists
- Voter Registration information, including eligible voter lists
- Various communications between voters and election officials, such as polling information, election
   notices, district boundaries, polling places, facilities and services provided, eligibility, etc.
- Ballot information (races, contests, issues, candidates, etc.)
- 30 Voter Authentication
- Vote Casting and Vote Confirmation
- Election counts, statistics and results
- Audit information pertinent to some of the other defined data and interfaces
- EML is flexible enough to be used for elections and referendums that are primarily paper-based or that are fully e-enabled.
- 36 This document and its accompanying set of schemas do not claim to satisfy the final requirements of any
- 37 and all registration or election systems. The specification represents our best current efforts, knowledge
- and experience with election systems since 2001. It is incumbent on the users of this document to identify
- 39 any requirement gaps, mistakes, inconsistencies or missing data and to propose corrections or
- 40 enhancements to the OASIS Election and Voter Services Technical Committee.

#### 1.1 Overview of the Document

- 42 To help establish context for the specifics contained in the XML schemas that make up EML, the
- 43 committee also developed a generic end-to-end election process model. This model identifies the
- significant components and processes common to many elections and election systems, and describes
- 45 how EML can be used to standardize the information exchanged between those components.
- Section 2 outlines the business and technical needs the committee is attempting to meet, the challenges
- 47 and scope of the effort, and introduces some of the key framing concepts and terminology used in the
- 48 remainder of the document.

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- 49 Section 3 describes two complementary high-level process models of an election exercise, based on the
- 50 human and technical views of the processes involved. It is intended to identify all the generic steps
- 51 involved in the process and highlight all the areas where standardized data is to be exchanged or
- referenced. The discussions in this section presents details of how the messages and data formats
- 53 detailed in the EML specifications themselves can be used to achieve the goals of open interoperability
- 54 between system components. Also contained in this Section are high-level data models showing the
- relationships of the data used in the election processes.
- 56 **Section 4** provides an overview of the approach that has been taken to creating the XML schemas.
- 57 **Section 5** provides descriptions of the core elements, data types and schemas developed to date.
- 58 Appendices provide information on internet voting security concerns; use of the EML defined TimeStamp
- schema; the W3C Digital Signature technology; and Acknowledgements and a revision history.

# 1.2 Terminology

- 62 The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD
- NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described
- 64 in [RFC2119].

#### 1.3 Normative References

- 66 [RFC2119] S. Bradner, Key words for use in RFCs to Indicate Requirement Levels,
- 67 http://www.ietf.org/rfc/rfc2119.txt, IETF RFC 2119, March 1997.

#### 68 1.4 Non-Normative References

- 69 [xNAL] OASIS Committee Specification 03 "eXtensible Name and Address (xNAL)
- 70 Specifications and Description Document Version 3.0" October 2008
- 71 http://docs.oasis-open.org/cig/v3.0/specs/cig-specs-v3.pdf
- 72 **[UK's APD]** Address and Personal Details Fragment v1.1 Technology Policy Team, e-Government
  - Unit, Cabinet Office UK, 1 March 2002
  - http://www.govtalk.gov.uk/interoperability/draftschema\_schema.asp?schemaid=92
- 75 **[XML]** Extensible Markup Language (XML) 1.0 (Third Edition) Tim Bray et al, Worldwide Web
  - Consortium, 4 February 2004 http://www.w3.org/TR/REC-xml
  - [XML-DSig] XML-Signature Syntax and Processing Donald Eastlake et al, Worldwide Web
- 78 Consortium, 10 June 2008 http://www.w3.org/TR/xmldsig-core/
- 79 [VoiceXML] Voice Extensible Markup Language (VoiceXML) Version 2.0 Scott McGlashan et al
- 80 Worldwide Web Consortium 16 March 2004 http://www.w3.org/TR/voicexml20

# 2. Introduction

#### 2.1. Business Drivers

Voting is one of the most critical features in our democratic process. In addition to providing for the orderly transfer of power, it also cements the citizen's trust and confidence in an organization or government when it operates efficiently. In the past, changes in the election process have proceeded deliberately and judiciously, often entailing lengthy debates over even the minutest detail. These changes have been approached with caution because discrepancies with the election system threaten the very principles that make our society democratic.

Society has become network oriented and citizens, used to the high degree of flexibility in the services provided by the private sector and in the Internet in particular, are now beginning to set demanding standards for the delivery of services by governments using modern electronic information systems.

The implementation of electronic voting (e-voting) has become globally widespread allowing increased access to information in the voting process for citizens everywhere and offering the scope for better verification and oversight for election supervision procedures. Allowing better access to information with consistent transparency and verification of results across the whole election process helps foster greater engagement and participation of voters throughout the whole democratic process itself. This also requires that standards ensure that the process is clear, robust and precisely understood so that confidence in the results is ensured. Access to a standard process also allows solution vendors to participate in an open marketplace that stimulates cost effective delivery and adoption of new technology without obsolescing existing investments.

However, it is recognized that more traditional verification methods and oversight will continue to be vital and in fact more so with the use of technology. Strong democracy requires participation from citizens and continuous independent monitoring of processes, procedures and outcomes. The OASIS EML standard seeks to facilitate precisely that transparency, access and involvement for citizens to the election process, end to end.

#### 2.2. Technical Drivers

In the election industry today, there are a number of different service vendors around the world, all integrating different levels of automation, operating on different hardware platforms and employing different solution architectures. With the global focus on e-voting systems and initiatives, the need for a consistent, auditable, automated and interoperable election system has never been greater.

The introduction of end-to-end open standards for election solutions is intended to enable election officials around the world to build upon existing infrastructure investments to evolve their systems as new technologies emerge. This will simplify the election process in a way that was never possible before. Open election standards as such aim to instill confidence in the democratic process among citizens and government leaders alike, particularly within emerging democracies where the responsible

implementation of the new technology is critical.

#### 2.3. The E&VS Committee

- 121 OASIS, the XML interoperability consortium, formed the Election and Voter Services Technical
- 122 Committee to standardize election and voter services information using XML. The committee is focused
- on delivering and maintaining a reliable, accurate and trusted XML specification (Election Markup
- Language (EML)) for the structured interchange of data and referencing of data among hardware,
- software and service vendors who provide election systems and services.
- 126 EML is the leading XML specification of its kind. When implemented, it can provide a uniform, secure and
- verifiable way to allow e-voting systems to interact as global election processes evolve and are adopted.
- 128 The Committee's mission statement is:
- "To develop a standard for the structured interchange of data among hardware, software, and service
   providers who engage in any aspect of providing election or voter services, be they partly paper-based or
   fully e-enabled, to public or private organizations. The services performed for such elections and
   referenda include but are not limited to:
  - candidate nomination.
    - referendum options nomination,
- voter registration,
- polling places, districting and boundaries
- various communications between voters and elections officials,
- 138 ballot information
- 139 voter authentication
  - vote casting and vote confirmation
- election counts, statistics and results."

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- The primary function of an electronic voting system is to capture voter preferences reliably, securely and report them accurately with legally requirements for privacy met correctly. Capture is a function that
- occurs between 'a voter' (individual person) and 'an e-voting system' (machine). It is critical that any
- election system be able to prove that a voter's choice is captured correctly and anonymously, and that the vote is not subject to tampering, manipulation or other frauds.
- These universal democratic principles<sup>1</sup> can be summarized as a list of fundamental requirements, or 'six commandments', for electronic voting systems:
- 150 1 Keep each voter's choice an inviolable secret.
- 151 2 Allow each eligible voter to vote only once, and only for those offices for which he/she is authorized to cast a vote.
- 153 3 Do not permit tampering with the voting systems operations, nor allow voters to sell their votes.

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<sup>&</sup>lt;sup>1</sup> First developed by Dr. Michael Ian Shamos, a PhD Researcher who worked on 50 different voting systems since 1980 and who reviewed the election statutes in half the US states, along with review from other researchers on e-voting principles.

- 154 4 Report all votes accurately
- 155 5 The voting system shall remain operable throughout each election.
- 156 6 Keep an audit trail to detect any breach of [2] and [4] but without violating [1].
- In addition to these business and technical requirements, the committee was faced with the additional challenges of specifying a requirement that was:
- Multinational our focus is to have these standards adopted globally
- Effective across the different voting regimes for example, proportional representation or 'first past the post', preferential voting, additional member system
- Multilingual our standards will need to be flexible enough to accommodate the various languages
   and dialects and vocabularies
- Adaptable our aim is to provide a specification that is resilient enough to support elections in both
   the private and public sectors
  - Secure the standards must provide security that protects election data and detects any attempt to corrupt it.
  - The Committee has followed these guidelines and operated under the general premise that any data exchange standards must be evaluated with constant reference to the public trust.

# 171 **2.4. Challenge and Scope**

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The goal of the committee has been to develop an Election Markup Language (EML) for end-to-end use within the election process. This is a set of data and message definitions described as a set of XML schemas and covering a wide range of transactions that occurs end-to-end during various phases and stages of the life cycle of an election. To achieve this, the committee decided that it required a common terminology and definition of election processes that could be understood internationally. The committee therefore started by defining the generic election process models described here.

- These processes are illustrative, covering the vast majority of election types and forming a basis for defining the Election Markup Language itself. EML has been designed such that elections that do not follow this process model should still be able to use EML as a basis for the exchange of election-related messages.
- EML is focused on defining open, secure, standardized and interoperable interfaces between components of election systems and thereby providing transparent and secure interfaces between various parts of an election system. The scope of election security, integrity and audit included in these interface descriptions and the related discussions are intended to cover security issues pertinent only to the standardized interfaces and not to the internal or external security requirements of the various components of election systems.
- 188 The security requirement for the election system design, implementation or evaluation must be placed within the context of the vulnerabilities and threats analysis of a particular election scenario. As such the 189 190 references to security within EML are not to be taken as comprehensive requirements for all election 191 systems in all election scenarios, nor as recommendations of sufficiency of approach when addressing all 192 the security aspects of election system design, implementation or evaluation. In fact, the data security mechanisms described in this document are all optional, enabling compliance with EML without regard for 193 194 system security at all. It is anticipated that implementers may develop a complementary document for a 195 specific election scenario, which refines the security issues defined in this document and determines their 196 specific strategy and approach by leveraging what EML provides.
- 197 EML is meant to assist and enable the election process and does not require any changes to traditional 198 methods of conducting elections. The extensibility of EML makes it possible to adjust to various e-
- 199 democracy processes without affecting the process. Conceptually EML simply enables the exchange of

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200 data between the various end-to-end election stages and processes in a standardized way.

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The solution outlined in this document is non-proprietary and will work as a template for any election scenario using electronic systems for all or part of the process. The objective is to introduce a uniform and reliable way to allow election systems to interact with each other. The OASIS EML standard is intended to reinforce public confidence in the election process and to facilitate the job of democracy builders by introducing guidelines for the selection or evaluation of future election systems.

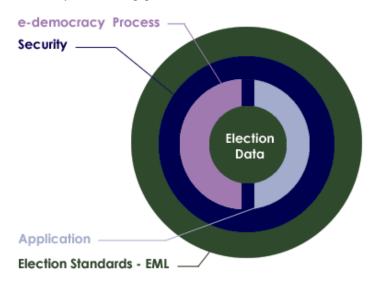


Figure 1A: e-Voting Components Relationship Overview

#### 2.5. Documentation Set

To meet our objectives, the committee has defined a process model that reflects the generic processes for running elections in a number of different international jurisdictions. The processes are illustrative, covering a large number of election types and scenarios.

The next step was then to isolate all the individual data items that are required to make each of these processes function. From this point, our approach has been to use EML as a simple and standard way of exchanging this data across different electronic platforms. Elections that do not follow the process model can still use EML as a basis for the exchange of election-related messages at interface points that are more appropriate to their specific election processes. The EML standard is being used in a number of situations across a number of different international jurisdictions.

The document set comprises:

- **Specification:** This document. A general and global study of the electoral process. This introduces the transition from a complete manual election management process to a digitally enabled end-to-end election system by defining the data structures of content to be exchanged and or produced and where these data structures are needed, and describe how those exchanges and artifacts are encoded as XML schemas.
- **Data Requirements:** A data dictionary defining the data used in the processes and required to be handled by the XML schemas. The data dictionary is provided in both XML and spreadsheet formats. In addition there are data models available in the 'EML v6.0 Data Models' file.
- **EML Schemas:** This consists of a library of the XML schemas used in EML. The XML schemas define the formal structures of the election data that needs to be processed throughout an election.

- EML Core Components Dictionary: A dictionary containing full definitions of the elements and data types used by the EML Core schema. The core dictionary is provided in both XML and spreadsheet formats.
  - **Templates:** for each schema a template is provided that facilitates generation of localizations of the main schema structure, creation of test case examples and implementation documentation. This aims to reduce implementer's costs of development and integration.

# 2.6. Voting Terminology

At the outset of our work, it was clear that the committee would need to rationalize the different terms that are commonly used to describe the election process.

Terms used to describe the election process, such as ballot and candidate, carry different meanings in different countries – even those speaking the same language. In order to develop a universal standard, it is essential to create universal definitions for the different elements of the election process. See the Data Dictionary for the terms used by the committee in this document

Our approach was to regard elections as involving Contests between Candidates or Referendum Options which aggregate to give results in different Elections.

In practice however, electoral authorities would often run a number of different elections during a defined time period. This phenomenon is captured in our terminology as an Election Event. Figure 1B uses a national parliamentary election process context to describe our approach in general terms.

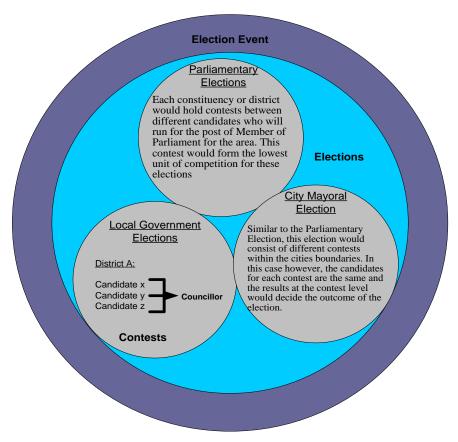


Figure 12B: The Election Hierarchy

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In Figure 1C, there is an Election Event called the 'Union Annual Election'. This comprises two Elections, one for the National Executive Committee (NEC) and one for the International Liaison Committee (ILC). Three positions are being selected for each committee; as a result, each Election is made up of three Contests. In region 1 (R1), the Contest for each Election has two Candidates.

Figure 1C shows the three Ballots (one for each region). The Ballot is personal to the voter and presents the Candidates available to that voter. It also allows choices to be made. During the election exercise, each voter in region 1 (R1) receives only the region 1 ballot. This ballot will contain the Candidates for the R1 contest for each of the two Elections.

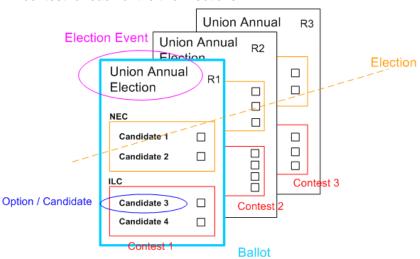


Figure 13C: Union Annual Election Event

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# 3. High-Level Election Process

Section 3 describes two complementary high level process models of an election exercise, based on the human and technical views of the processes involved. It is intended to identify all the generic steps involved in the process and highlight all the areas where data is to be exchanged.

First two diagrams are presented (Figures 2a and 2B below) that illustrate these process models and then the section continues by providing details pertaining to the models and illustrative real world processes they introduce.

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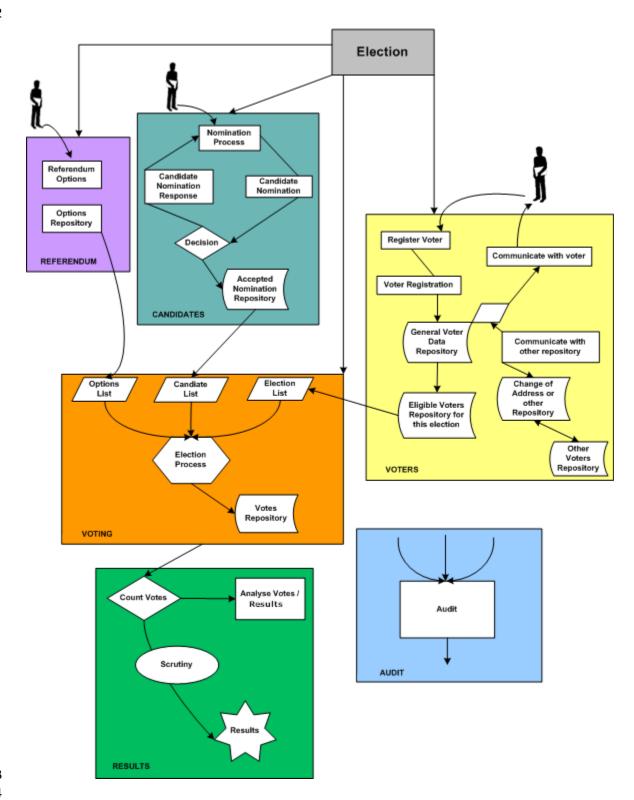
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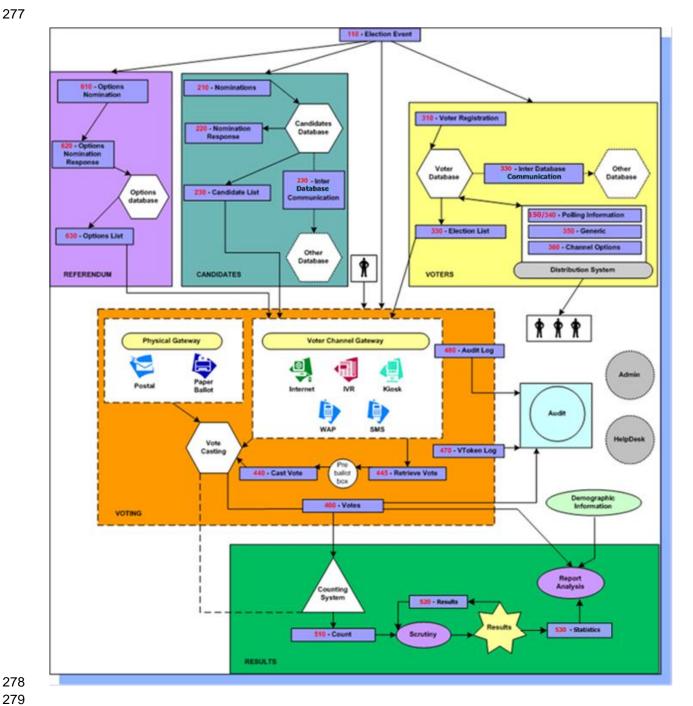
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#### 282 **3.1. Outline**

This *high-level process model* is derived from real world election experience and is incorporates knowledge gained over the past 8 years of refining and improving the specification for EML.

For clarity, the whole process can be divided into 3 major areas, pre election, election, post election; each area involves one or more election processes. This document allocates a range of numbers for each process. One or more XML schemas are specified to support each process, this ensures consistency with all the figures and the schemas required:

- 289 Pre election
- 290 Election (100)
- 291 Candidates (200)
- 292 Options (600)
- 293 Voters (300)
- 294 Election
- 295 Voting (400)
- 296 Post election
- 297 Results (500)
- 298 Audit
- 299 Analysis
- 300 Some functions belong to the whole process and not to a specific part:
- Administration Interface
- 302 Help Desk

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#### 303 3.2. Process Descriptions

### 3.2.1. The Candidate Nomination Process

This is the process of approving nominees as eligible candidates for certain positions in an election. A candidate in this context can be a named individual or a party.

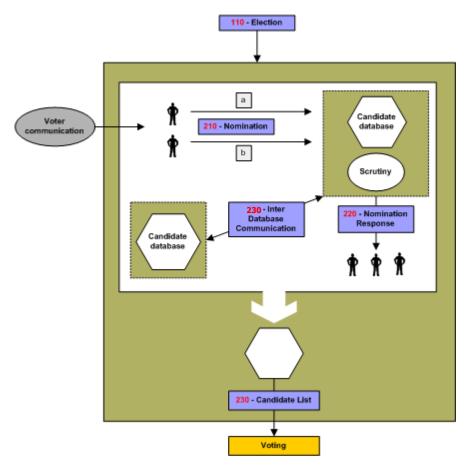


Figure 2C: The Candidate Nomination Process

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Irrespective of local regulations covering the nomination process, or the form in which a candidate's nomination is to be presented, (e.g. written or verbal), the committee anticipates that the process will conform to the following format:

- Voter Communications [350-Generic] declaring the opening of nominations will be used to reach the population eligible to nominate candidates for a position x in an election y.
- Interested parties will respond in the proper way satisfying the rules of nomination for this election with the objective of becoming running candidates. The response message conforms to schema 210.
  - A nomination for an individual candidate can be achieved in one of two ways:
  - A Nominee will reply by attaching to his nomination a list of x number of endorsers with their signature.
- Each endorser will send a message specifying Mr. X as his or her nominee for the position in question. Mr X will signal his agreement to stand.
  - Note that nomination and the candidate's agreement to stand might be combined in a single message or sent as two messages, each conforming to schema 210.
- The election officer(s) of this specific election will scrutinize those replies by making sure the requirements are fully met. Requirements for nomination vary from one election type to another, for example some elections require the nominee to:
- 327 Pay fees,

- 328 Have x number of endorsers,
- 329 Be of a certain age,
- Be a citizen more than x number of years,
- Not stand for election in more than one contest at a time,
- 332 Etc

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- Schema 210 provides mechanisms to identify and convey scrutiny data but since the laws of nomination vary extensively between election scenarios, no specific scrutiny data is enumerated.
- Schema 330 allows election officials to enquire of other jurisdictions whether a particular candidate is standing in more than one contest.
- Nominees will be notified of the result of the scrutiny using a message conforming to schema 220.
  - The outcome of this process is a list of accepted candidates that will be communicated using a message conforming to schema 230. It will be used to construct the list of candidates for each contest.

# 3.2.2. The Options Nomination Process

This is the process of approving the options to be presented to voters in a referendum. The options can be a straight choice, e.g. YES or NO, to a single question, or can be more complex involving choices to a number of questions and/or preferences of choice.

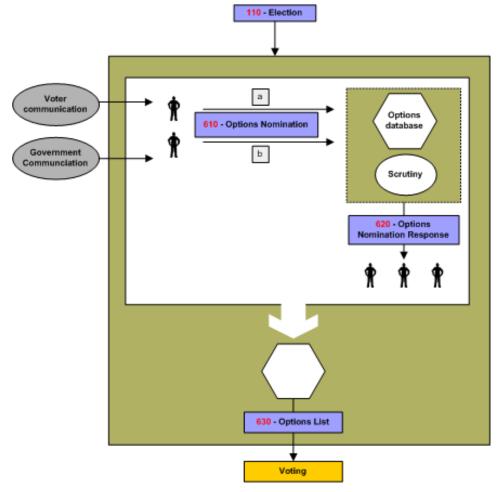


Figure 2D: Referendum Options Nomination Process

The nomination can be received in a number of ways including direct from government institutions or from citizens or businesses, and schema 610 handles the receipt of nominations.

Nominees may be notified of the result of any scrutiny of their nomination using a message conforming to schema 620.

The outcome of this process is a list of accepted options that will be communicated using a message conforming to schema 630. It will be used to construct the list of referendum questions for each contest.

# 3.2.3. The Voter Registration

This is the process of recording a person's entitlement to vote on a voter registration system. A key part of this process is the identification of the person.

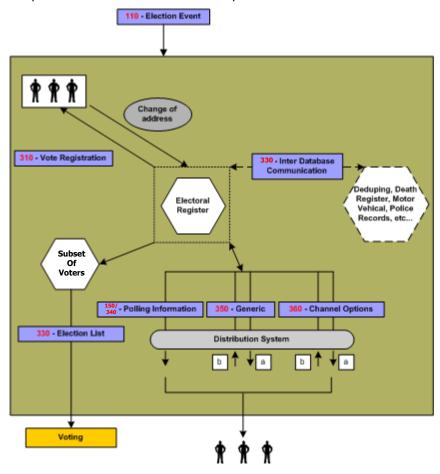


Figure 2E: Voter Registration

The centre of this process is the Electoral Roll Database or the Voters' Database. The input into this database is the outcome of communications between 'a voter' and 'an Election Authority'. The subject of this correspondence can vary from adding a voter to modifying a voter; deletion of a voter is considered as part of modification.

This schema of data exchange is recommended irrelevant of the method a voter uses to supply his information. For example, a voter could register online or simply by completing a voter's form and posting

- 365 the signed form. In the latter case, this schema is to be followed when converting the paper form into the 366 electoral database.
- 367 Another potential communication or exchange of data is with other databases such as those used by 368 another election authority, government body, etc. Database exchanges will be required in some election
- 369 scenarios; examples include geographical and organizational boundary changes.
- 370 At a certain date, a subset of the voters' database is fixed from which the election list is generated.
- Schemas contain some subset of the eligible voters, perhaps grouped by polling district or voting channel. 371
- 372 It is here that we introduce the concept of voter communications. Under this category we divided them into three possible types of communications: 373
- Channel options 374
- 375 Polling Information
- 376 Generic.

377 The communication method between the Election Authority and the voters is outside the scope of this 378 document, so is the application itself. This document does specify the data needed to be exchanged.

## 3.2.4. The Voting Process

380 This is the process that involves the authentication of the voter and the casting of an individual vote.

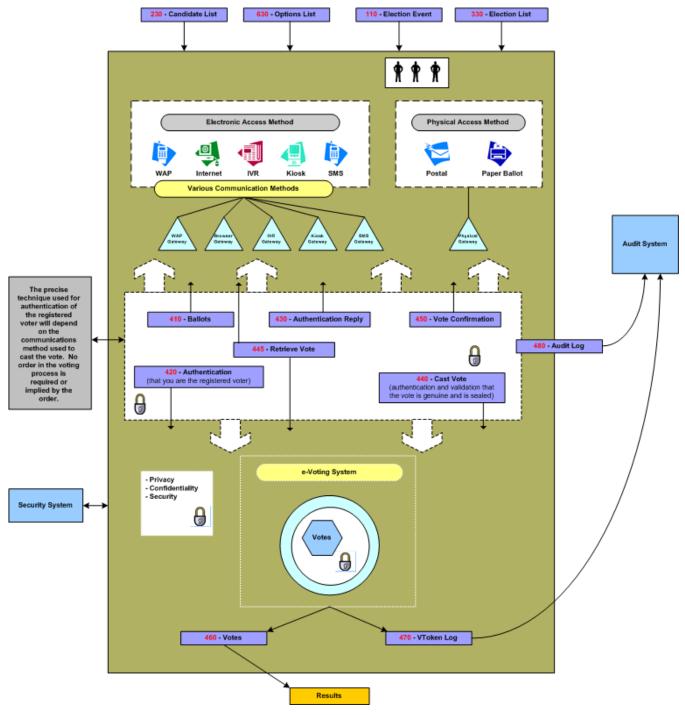


Figure 2F: The Voting Process

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We assumed various systems would be involved in providing the voting process and regard each system as an independent entity.

As this figure shows, the voter will be voting using a choice of physical channels such as postal or paper ballot (the 'physical access methods'), or the voter can vote using 'electronic access methods' where he/she can utilize a number of possible e-voting channels.

Each channel may have a gateway acting as the translator between the voter terminal and the voting system. Typically, these gateways are in proprietary environments. The following schemas are to be used when interfacing to such gateways: 410, 420, 430, 440 and 450. These schemas should function irrespective of the application or the supplier's favored choice of technology.

When a pre-ballot box is required in a scenario, schema 445 can be used to retrieve and amend votes before they are counted.

Where a voter's right to vote in any particular contest needs to be determined, this is defined by the parameters of his VToken. See Section 4 for more information on security and the VToken.

In some scenarios the right to vote may need to be qualified. This may occur if the voter's right to vote is challenged or if the voter is given the temporary right to vote. In this case the vote needs to be cast by a voter with a Qualified VToken. The reason for the qualification shall always be present in a Qualified VToken and the qualification may need to be investigated before the vote is counted as legitimate. The VToken and Qualified VToken are part of schemas 420, 440, 450, 460 and 470.

To create balloting information, input data is needed about the election, the options/candidates available and the eligible voters; see schemas 230, 110 and 330 for exchanging such information between esystems.

## 3.2.5. The Vote Reporting Process

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Two of the post election items are the Final or Interim Result and the Audit Report. Audit is discussed in 3.4.6.

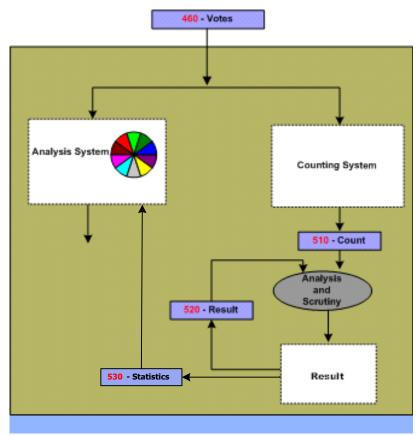


Figure 2G: The Vote Reporting Process

- The voting system should communicate a bulk of data representing the votes to the counting system or the analysis system-using schema 460. The count of these, which is the compilation of the 460, is to be
- 413 communicated by the schema 510.
- Recount can be very simply accommodated by a re-run of the schema 460, on the same or another counting system.
- Some voting methods, such as the additional member system (AMS), combine the result of one election
- with the votes of another to create a result. For an election run under the AMS, the results of the 'first past
- the post' (FPP) election can be communicated using a message conforming to schema 520. This schema
- can only be used for communicating the results of elections using simple voting methods such as FPP,
- and is not intended as a general purpose results schema.
- The votes schema 460 also feeds into a variety of analysis systems, which can be used to provide for
- demographic, statistical or other types of election reports. The output of these analysis systems is outside
- the scope of this document.
- 424 Schemas 510 and 520 allow for Simulation and Extrapolation of final or interim Counts and Results.
- Simulation being the facility to forecast the result of a contest based on the result of another contest.
- 426 Extrapolation is the facility to forecast the final result of a contest based on the count so far.
  - Schema 530 allows for a variety of statistics to be extracted from the results and passed to analysis systems and other media outlets.

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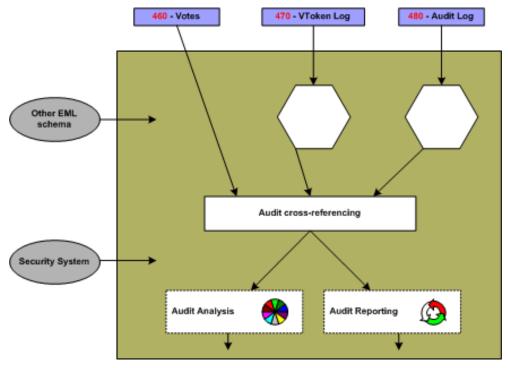
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# 3.2.6. The Auditing System

Audit is the process by which a legal body consisting of election officers and candidates' representatives can examine the processes used to collect and count the vote, thereby proving the authenticity of the result.



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Figure 2H: Auditing System

- A requirement is for the election officer to be able to account for all the ballots. A count of ballots issued should match the total ballots cast, spoiled and unused.
- Schemas 460, 470, 480 from the voting process provide input data to the audit process. Depending on
- the audit requirements additional data from other processes may be required. In particular, the security
- process may provide additional data about all the issued VTokens and Qualified VTokens (see Figure 3A:
- 442 Voting system security).
- The security process ensures that the right to cast a vote is dictated by the presence of a VToken, thus in
- order to provide accountability for all ballots as per the requirement above, reliable data from the security
- system is required on the total number of:
- 446 Eligible voters

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- Issued VTokens or Qualified VTokens.
- The audit process can collate the total number of VTokens and Qualified VTokens provided by the security system with the total number reported by the voting system using schema 460 and 470.
- The security system and sealing mechanism should be implemented so that trust can be placed in the
- 451 seal and hence the sealed data. This implies that the seal should be performed as close to the user
- 452 submission of the vote as technically possible. The count of the spoiled and unspoiled votes from 460 can
- 453 then be cross-checked against the count of the number of trusted seals from 480. This correlation
- confirms that the total number of votes presented by the output of the e-voting system in 460 is consistent
- with the total number of submitted votes with seals.
- The above correlation between trusted data provided by the security process and data provided by the
- voting process proves that no legitimate votes have been lost by the voting system. It also proves that
- 458 there is consistency between the number of eligible voters and the spoiled, unspoiled and unused votes
- as recorded by the e-voting system.
- Another requirement is for the election officer to be able to prove that voted ballots received and counted
- 461 are secure from any alteration. This requirement is met because each vote cast is sealed; the seal can be
- verified by the audit system and to prove that no alterations have been made since the vote was sealed.
- 463 A further requirement is for the election officer to be provided with a mechanism to allow a recount when
- a result is contested. The number of votes from the voting system using schema 460 can be verified by
- correlating the total votes as calculated by the audit system (using schema 480), with the totals from the
- 466 counting system. Then either re-running the count or running the count on another implementation can
- verify an individual result.
- There is also the requirement for the election officer to be provided with a mechanism that allows for
- 469 multiple observers to witness all the voting process. How this is achieved in dependant on the
- 470 implementation of the system and procedures adopted. However, the seals and channel information
- 471 using schema 480 provide the ability to observe voting inputs per channel while voting is in progress
- without revealing the vote itself or the voter's identity. The final count of the seals can then be used to
- 473 cross check the totals of the final result as described above.
- The above defines some of the election data that can be verified by the audit system. However, ideally
- everything done by the various components of an election system should be independently verifiable. In
- 476 the scope of EML this means that the audit system may need to be able to process all the standardized
- 477 EML schemas. The audit system may in addition support proprietary interfaces of voting systems to
- 478 enhance visibility and correctness of the election process.

# 3.3. Data Requirements

- Shown below at Fig 2i is a high-level data model of the data used in the above processes. Further lower-
- 481 level data models are available in the 'EML v6.0 Data Models' file and all the data are defined in 'EML
- v6.0 Data Dictionary'. Fig 2j below shows the mapping between the data entities and the EML schemas.

# EML v6.0 Top Level Data Model

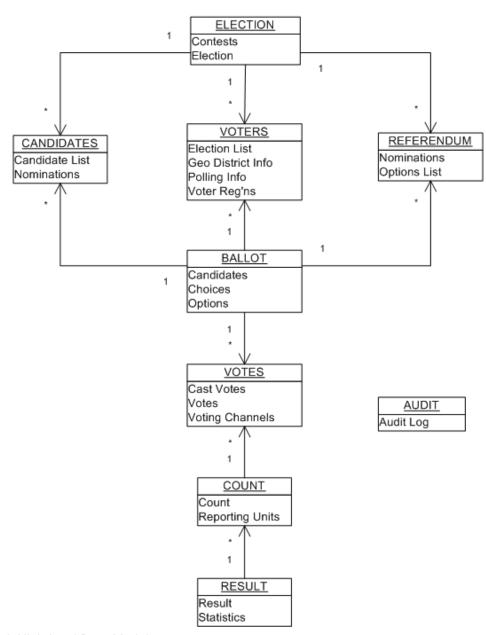
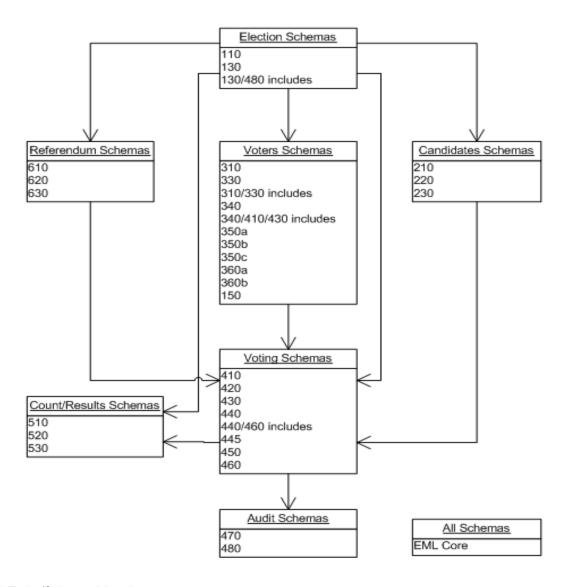


Figure 2i: High-level Data Model

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# EML v6.0 Entity/Schema Correlation



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Fig 2j Entity/Schema Mapping

# 4. Schema Outline

#### **491 4.1. Structure**

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The Election Markup Language specification defines a vocabulary (the EML core) and message syntax (the individual message schemas). Thus most voting-related terms are defined as elements in the core with the message schemas referencing these definitions. The core also contains data type definitions so that types can be re-used with different names (for example, there is a common type to allow messages in different channel formats), or used as bases for deriving new definitions.

- In some cases, two or more message schemas have large parts in common. For example, a voter authentication response message can contain a ballot that is almost identical to that used in the ballot message. When this occurs, the relevant declarations are included in a file whose file name includes the word 'include' and the number of the schemas in which it is used.
- There is a third category of schema document within EML the EML externals. This document contains definitions that are expected to be changed on a national basis. Currently this comprises the name and address elements, which are based on the OASIS Extensible Name and Address Language [1], but may be replaced by national standards such as those contained in the UK Government Address & Personal Details schemas [2]. Such changes can be made by replacing just this single file.
- As well as these, several external schemas are used. The W3C has defined a standard XML signature [5]. OASIS has defined schemas for the extensible Name and Address Language (xNAL) [1]. As part of the definition of EML, the committee has defined a schema for the Timestamp used within EML. All these schemas use their appropriate namespaces, and are accessed using xs:import directives.
- Each message (or message group) type is specified within a separate schema document. All messages use the EML element from the election core as their document element. Elements declared in the individual schema documents are used as descendents of the EML element.
- As an international specification, EML is generic in nature, and so needs to be tailored for specific scenarios. Some aspects of the language are indicated in EML as required for all scenarios and so can be used unchanged. Some aspects (such as the ability to identify a voter easily from their vote) are required in some scenarios but prohibited in others, so EML defines them as optional. Where they are
- 517 prohibited, their use must be changed from an optional to prohibited classification, and where they are 518 mandatory, their use must be changed from an optional to required classification.

## 4.2. Viewing Schemas

- 520 EML schemas are supplied as text documents. For viewing the structure of the schemas, we recommend 521 the use of one of the many schema development tools available. Many of these provide graphical 522 displays.
- 523 **4.3. IDs**

- 524 XML elements may have an identifier which is represented as an Id attribute.
- Each schema element has an Id attribute that relates to the message numbering scheme. Each message also carries this number.
- Some items will have identifiers related to the voting process. For example, a voter might be associated with an electoral roll number or a reference on a company share register. These identifiers are coded as
- 529 elements.
- 530 Other identifiers exist purely because of the various channels that can be used for voting (e.g. Internet,
- 531 phone, postal, etc). In this case the identifiers are likely to be system generated and are coded as
- 532 attributes.

## 4.4. Displaying Messages

Many e-voting messages are intended for some form of presentation to a user, be it through a browser, a mobile device, a telephone or another mechanism. These messages need to combine highly structured information (such as a list of the names of candidates in an election) with more loosely structured, often channel-dependent information (such as voting instructions).

Such messages start with one or more Display elements, such as:

```
539
          <?xml version="1.0" encoding="UTF-8"?>
540
          <FMT.
            Id="410"
541
542
            SchemaVersion="6.0"
543
            xml:lang="en"
544
            xmlns="http://www.govtalk.gov.uk/temp/voting"
545
            xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
546
            xsi:schemaLocation="http://www.govtalk.gov.uk/temp/voting
547
                                 ..\schemas\ballot.xs">
548
            <Display Format="html">
549
              <Stylesheet Type="text/xsl">../stylesheets/ballot.xsl</Stylesheet>
550
              <Stylesheet Type="text/css">../stylesheets/eml.css</Stylesheet>
551
            </Display>
552
            <Ballots>
553
```

This example shows a Display element providing information to the receiving application about an XSL stylesheet which transforms the message into HTML for displaying the ballot in a Web browser. In the Display element in the example, the XSLT stylesheet reference is followed by a CSS stylesheet reference. In this case, the XSLT stylesheet referenced will pick up the reference to the CSS stylesheet as it transforms the message, and generate appropriate output to enable the displaying browser to apply that cascading stylesheet to the resulting HTML.

Not all information in a message will need to be displayed, and the creator of the message might have views on the order of display of the information. To allow stylesheets to remain generic, many elements in the schemas can have a DisplayOrder attribute. The values of these attributes determine the layout of the display (or the spoken voice if transforming to, for example, VoiceXML), even when using a generic stylesheet.

When displaying messages in HTML, the expectation is that generic stylesheets will cover most cases, with the stylesheet output being embedded in a web page generated from an application-specific template. Similarly, voice applications might have specific welcome and sign-off messages, while using a generic stylesheet to provide the bulk of the variable data.

The three screen shots show the effect of using the same XSL stylesheet on the ballots for various voting scenarios. In the first picture, clicking on the name of a candidate has popped up a window with additional details.

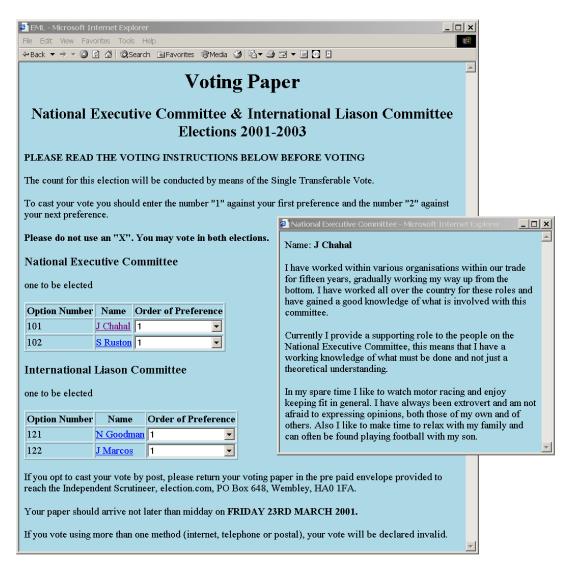


Figure 3A: Screen shot of the ballot for scenario 1

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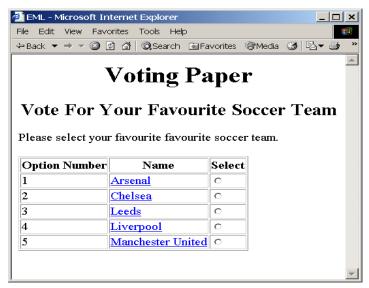


Figure 3B: Screen shot of the ballot for scenario 2

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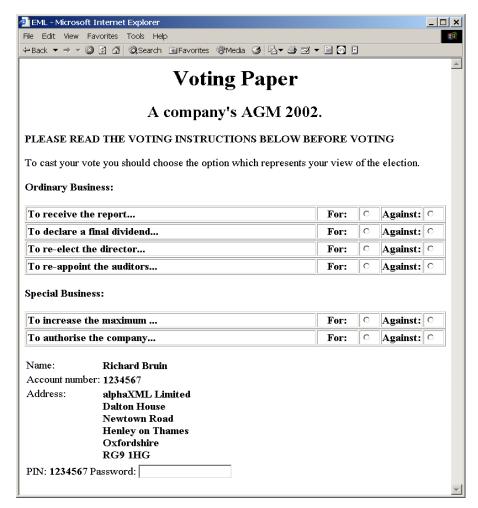


Figure 3C: Screen shot of the ballot for scenario 3

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#### 4.5. EML Message Validation

It is up to each specific system implementation whether it uses these schemas for validation of EML messages for either testing or live use. The recommended approach is to validate incoming messages against the EML schemas (with the application-specific EML externals schema), then further validate against the relevant Schematron schema or OASIS CAM template. The first stage requires the use of an XML processor (parser) that conforms to W3C XML Schema. The second stage requires either an XSLT processor or a dedicated Schematron or CAM processor.

- However, an implementation may choose to:
- modify the EML schemas to incorporate those application-specific constraints that can be represented in W3C XML Schema;
- not validate the rules that are encoded as templates schemas (Schematron or CAM);
- not perform any validation; or
- develop some alternative backend validation.

## 4.6. Namespaces

- 596 The message schemas and the core schema are associated with the namespace
- urn:oasis:names:tc:evs:schema:eml. This is defined using the prefix eml. The XML Schema
- namespace http://www.w3c.org/2001/XMLSchema is identified by the prefix xs and the XML
- 599 Schema Instance namespace http://www.w3.org/2001/XMLSchema-instance by the prefix xsi.
- Use is also made of namespaces for the Extensible Name and Address Language (xNAL). The
- Extensible Name Language namespace urn:oasis:tc:ciq:xsdschema:xNL:3.0 is identified by the
- prefix xNL, and the Extensible Language namespace
- 603 urn:oasis:names:tc:ciq:xsdschema:xAL:3.0 by the prefix xAL.

# 4.7. Extensibility

Various elements allow extensibility through the use of the xs: any element. This is used both for display information (for example, allowing the sending of HTML in a message) and for local extensibility. Note that careless use of this extensibility mechanism could reduce interoperability.

#### 4.8. Additional Constraints

The EML schemas provide a set of constraints common to most types of elections worldwide. Each specific election type will require additional constraints, for example, to enforce the use of a seal or to ensure that a cast vote is anonymous. It is recommended that these additional constraints be expressed using the Schematron language although other validators, e.g. OASIS CAM, can be used. This allows additional constraints to be described without altering or interacting with the EML schemas. Any document that is valid to a localization expressed in Schematron must also be a valid EML document.

#### 4.9. Metadata

Some messages need information relating to the issuing of them, such as the issue date, who issued them etc. This is most likely to be a requirement for the 330 message but is equally applicable to 130, 230, 350a and several others. For that reason, it is useful to make this optional information available in the header. The information usually consists of: managing authority, date of issue, start of list period (used for changes to the list to indicate the start of the period for which changes are being shown), end of list period (i.e. the date of the snapshot of the list).

# 4.10. Splitting of Messages

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There is sometimes a need to split long messages into several parts. By their nature, each of these messages will contain a small amount of background information and a single element type that is repeated many times. For example, the 330-electionlist message can have many VoterDetails elements.

When a message is split, each part must be a complete, valid EML document. This will contain all the elements required by EML and the specific application. Those parts outside the repeated element that relate to the message as a whole, such as the TransactionId, must have the same values in each part message. The values of those elements and attributes that relate to an individual part message, such as the SequenceNumber, may vary between the individual part messages. Information in the EML element indicates the sequence number of the message and the number of messages in the sequence. Each message in the sequence must contain the same TransactionId, and must indicate the repeated element according to the table below. Only the messages shown in the table may be split in this way.

| Message                | Repeated Element |
|------------------------|------------------|
| 330-electionlist       | VoterDetails     |
| 340-pollinginformation | Polling          |
| 410-ballots            | Ballot           |
| 460-votes              | CastVote         |
| 470-vtokenlog          | VTokens          |
| 480-auditlog           | LoggedSeal       |

For ease of implementation, a message that can be split may contain the elements used for splitting even if the entire message is sent in one piece. In this case, the values of SequenceNumber and NumberInSequence will both be "1".

## 4.11. Error Messages

The 130 schema is used to define a message for reporting errors in EML messages.

640 Error messages are given codes. These fall into one of five series:

| 1000 | XML well-formedness or Schema validation |  |
|------|--|--|
|      | error                                    |  |
| 2000 | Seal error                               |  |
| 3000 | EML rule error                           |  |
| 4000 | Localization rule error                  |  |
| 5000 | System specific error                    |  |

If the error type is not message-specific (or is a general rule applying to several schemas), the series reference above is used. If it is message-specific, the last three digits of the error series (and possibly a final alpha character) reflect the message type. A three digit error code is appended to the series code, separated by a hyphen.

An error code relating to a localisation applicable to all message types could therefore be 4000-001. One specific to the localization of schema 110 could be 4110-002.

#### 4.12. All Schemas

#### 4.12.1. XML well-formedness or Schema validation error

|            | l                 |
|------------|-------------------|
| Error code | Error Description |
| Lift Couc  | Ellor Description |

| 1000-001 | Message is not well-formed |
|----------|----------------------------|
| 1000-002 | Message is not valid       |

# **4.12.2. Seal Errors**

| Error code | Error Description                |
|------------|----------------------------------|
| 2000-001   | The Seal does not match the data |

# 650 4.12.3. EML Additional Rules

The following rules apply to messages regardless of localization. One of the two rules on splitting will apply to each message type as described in the table below.

| Error Code | Error Description   |
|------------|---|
| 3000-001   | If there are processing units in the AuditInformation, one must have the role of sender   |
| 3000-002   | If there are processing units in the AuditInformation, one must have the role of receiver |
| 3000-003   | This message must not contain the elements used for splitting                             |
| 3000-004   | The value of the Id attribute of the EML element is incorrect                             |
| 3000-005   | The message type must match the Id attribute of the EML element                           |
| 3000-006   | All messages that are split must include the correct sequenced element name.              |

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|      | 3000-003 | 3000-006 |
|------|----------|----------|
| 110  | ✓        |          |
| 130  | ✓        |          |
| 150  | ✓        |          |
| 210  | ✓        |          |
| 220  | ✓        |          |
| 230  | ✓        |          |
| 310  | ✓        |          |
| 330  |          | ✓        |
| 340  |          | ✓        |
| 350a | ✓        |          |
| 350b | ✓        |          |
| 350c | ✓        |          |

| 360a | ✓        |   |
|------|----------|---|
| 360b | ✓        |   |
| 410  |          | ✓ |
| 420  | ✓        |   |
| 430  | ✓        |   |
| 440  | ✓        |   |
| 445  | ✓        |   |
| 450  |          | ✓ |
| 460  |          | ✓ |
| 470  |          | ✓ |
| 480  |          | ✓ |
| 510  | ✓        |   |
| 520  | ✓        |   |
| 530  | ✓        |   |
| 610  | ✓        |   |
| 620  | <b>√</b> |   |
| 630  | ✓        |   |

# **5. Schema Descriptions**

# 5.1 Overview

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The following table presents a high-level overview of the EML schemas. Further explanations are given in the following sub-paragraphs.

| Schema Name                       | Purpose   |  |
|-----------------------------------|---|--|
| EML 110 – election event          | Information about an election or set of elections. It is usually used to communicate information from the election organizers |  |
| EML 130 – response                | Report error response. Contains details of the message received that was in error.  |  |
| EML 150 – geographic district     | Allow use of geographic mapping systems to describe the election districts and boundaries and balloting                       |  |
| EML 210 – candidate nomination    | Used to nominate candidates or parties, consenting or withdrawing   |  |
| EML 220 – response to nomination  | Use to confirm whether the candidate's nomination has been accepted.  |  |
| EML 230 – candidate list          | Contest and candidates details  |  |
| EML 310 – voter registration      | Used to register voters for an election   |  |
| EML 330 – voter election list     | Details of actual voters for an election  |  |
| EML 340 – polling information     | Notification to voter of an election, their eligibility and how to vote   |  |
| EML 350a – outgoing generic       | Provides a common structure for communications to the voter.  |  |
| EML 350b – incoming generic       | Provides a common structure for communications from the voter.  |  |
| EML 350c – internal generic       | Provides a common structure for systems communications.   |  |
| EML 360a – outgoing channel       | Used for messages offering a set of voting channels to the voter  |  |
| EML 360b – incoming channel       | Used for messages defining a preferred voting channels of the voter   |  |
| EML 410 – ballot                  | Describes the actual ballot to be used for an election  |  |
| EML 420 – voter authentication    | Used for voter authentication during a voting process   |  |
| EML 430 – authentication response | Indicates whether authentication succeeded; may present the ballot to the user  |  |
| EML 440 – cast vote               | Actual record of vote cast  |  |
| EML 445 – retrieve vote           | For systems that include a pre-ballot box from which votes can be retrieved and confirmed                                     |  |
| EML 450 – confirm vote            | Show whether a vote has been accepted and provide a reference number or rejected.   |  |
| EML 460 – votes group             | Group of votes being transferred for counting   |  |
| EML 470 – vtoken log              | Add voting tokens to an audit log   |  |
| EML 480 – audit log               | Documents access to voting records and reason   |  |
| EML 510 – count                   | Results of election contest(s) and counts   |  |
| EML 520 – result                  | Communicating specific result details on candidates and elections   |  |
| EML 530 – statistics              | Provide statistical information about EML 510 counts and results  |  |
| EML 610 – options nomination      | Used to nominate the choice of options that will be included in a referendum.   |  |

EML 620 – options nomination Confirms whether the options nomination has been accepted. response

EML Core Defines the core definitions of the content model reused across the EML schemas

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### **5.2 EML Core Components**

- The EML Core schema contains elements and data types that are used throughout all the EML schemas.
- 663 For details see the EML core dictionary that is provided as separate files in XML and spreadsheet
- 664 formats. The core components are included in the EML Core schema that is imported into each EML
- 665 schema.
- The dictionary shows items in sequence and denotes their CCTS (Core Components Technical
- 667 Specification) classification based on their usage within EML structures. Those marked as BBIE (Basic
- Business Information Entity) are atomic pieces (element), while those marked as ABIE are Aggregate
- 669 entities consisting of more than one component (elements structure), while ASBIE equate to XML
- 670 attributes values for the associated BBIE elements. For complete discussion of Core Components
- 671 concepts see the UN/CEFACT Core Components specification
- 672 (http://www.unece.org/cefact/ebxml/CCTS\_V2-01\_Final.pdf).
- Related to classification of content type is the difference between Schema elements and types and
- specifically Schema xsd:complexType usage and this is discussed next.

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#### 5.2.1 Complex Data Types

The choice between defining an element or a data type for a reusable message component is a significant design issue. It is widely accepted as good practice to use element declarations when there is good reason to always refer to an element by the same name and there is no expectation of a need to derive new definitions. In all other cases, data type declarations are preferable. The term schema component is used to refer to elements and data types collectively.

When defining a complete mark-up language, limiting the use of elements and types can restrict further development of the language. For that reason, both data types and elements are defined in EML. Only where an element is an example of a primitive or derived data type defined in XML Schema Descriptions is no explicit data type defined within EML.

- In use, it is expected that, for example:
- A voting token will always have an element name VToken and so will use the element name.
- A logo or a map have similar definitions, so both use the PictureDataStructure. There is no PictureData element.
- Within voter identification, some elements will usually need to be made mandatory and so a schema will specify a new element based on the VoterIdentificationStructure data type.

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# 5.3 Message Schemas

- This section describes the EML messages and how the message specifications change for this application. It uses the element and attribute names from the schemas.
- 696 Election Event (110)
- This schema is used for messages providing information about an election or set of elections. It is usually used to communicate information from the election organisers to those providing the election service.
- The message therefore provides information about the election event, all elections within that event and all contests for each election.

- For the election event, the information includes the ID and name of the event, possibly with a qualifier on the event. This qualifier is used when an event has several local organisers. For example, for a UK general election, each constituency organises its own contests. The election event is therefore the general election, whilst the qualifier would indicate the constituency. Other information regarding an election event comprises the languages to be used, the start and end dates of the event, potentially a list of external documents that are applicable (such as the rules governing the election), a description and information about the managing authority.
- The managing authority can be indicated for the event, each election, each contest within the election and each reporting unit.
- An election can have a number of dates associated with it. For example, there is likely to be a period allowed for nomination of candidates and a date when the list of eligible voters is fixed. Each date can be expressed as a single date when something happens, a start date, an end date, or both start and end dates. These dates can be either just a date or both a date and time using the subset of the ISO 8601 format supported by XML Schema.
- Like the event, an election can have both a managing authority and referenced documents. Finally, there is a Messages element for additional information.
- A contest has a name and ID. It can also have reporting unit identifiers. A contest may need to specify its geographical area independently from its name, for which purpose the Area element is provided. Each contest can specify the voting channels allowed. In general, the list of possible channels will be further restricted as part of a local customisation. Each channel can specify several methods for authenticating the voter, such as PIN and password, and a response method, indicating the type of response to be given to a cast vote. Finally, facilities are provided to indicate the dates and times when the channel will be available to the voter.
- As described previously, a contest can indicate its managing authority. It may also indicate the position (such as 'President') for which votes are being cast. The Description allows for additional text describing the contest. Each contest indicates the voting method being used, whilst the CountingAlgorithm indicates the method of counting (such as the d'Hondt or Meeks method) that will be used. The minimum and maximum number of votes to be cast by each voter can also be indicated.
- A list of polling places can be provided. These can be either physical locations for people to go to vote, postal addresses for postal votes or electronic locations. An 'other location' is also allowed for cases where these do not meet the requirements. A location can also say when it will be available. This is intended for mobile polling stations that will only be available at a given address for a part of the voting period.
- Finally, a Messages element allows for additional information that might be communicated to the voter later through other messages.

#### **Additional Rules**

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| Error<br>Code | Error Description   |
|---------------|---|
| 3110-001      | The allowed channels must not be declared at both the election event level and the contest level. |

## Response (130)

Some messages have a defined response message that provides useful information. However, there is a need for a more general response, either to indicate that a message has been accepted, or to indicate the reasons for rejection.

- The message includes information to identify the message to which the response applies (by using the
- same transaction id in the EML element and, if necessary, including the sequence number of the message
- to which the response applies in the Response element), with information on the entity raising the
- message, whether the message was accepted and information about the errors if it was not. The desired
- 746 language for a display message can also be included to allow a downstream processor to substitute a
- 747 language-specific error message if required.
- 748 If the message is reporting an error, the location of the error within the message can be indicated.
- 749 Usually, this will be an XPath to the location of the error. However, errors detected by an XML parser may
- be in a different format, such as a line number.
- Note that a single response can be raised for a series of sub-messages with the same transaction ID.
- This allows indication, for example, that a sub-message was missing.

#### **Additional Rules**

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| Error Code | Error Description   |
|------------|---|
| 3130-001   | If the message is not accepted, there must be an Errors element |

### **754 GeoDistrict (150)**

- 755 This schema allows the use of geographic mapping systems to describe election districts and their
- 56 boundaries by providing information to voters to help their understanding of where and when they should
- go to cast their vote. For example information relating to the streets and polling places within a district, the
- name by which the district is identified to voters and physical features and landmarks describing a specific
- 759 polling place to be used in elections.
- Supplementary information about the districts and polling places to assist voters can also be recorded, for
- 761 example detailed descriptions in one or more language that describes the district, the political area or
- legislature that the district belongs to, the Authority that is responsible for managing elections in the
- 763 district, and access and facilities details about a specific polling place to be used in elections.
- This set of authorized information can be made available by any number of organisations through a variety of different outlets.

#### Candidate Nomination (210)

- 767 Messages conforming to this schema are used for four purposes:
- 768 1. nominating candidates in an election;
- 769 2. nominating parties in an election;
- 770 3. consenting to be nominated; or
- 771 4. withdrawing a nomination.
- Candidate consent can be combined in a single message with a nomination of the candidate or party or sent separately.
- Note that the message does not cover nomination for referendums.
- 775 The election and contest must be specified. When a candidate is being nominated, there must be
- information about the candidate and one or more proposers. The candidate must supply a name.
- Optionally, the candidate can provide contact information, an affiliation (e.g. a political party) and textual
- 778 profiles and election statements. These two items use the MessagesStructure to allow text in multiple
- 779 languages. There is also scope to add additional information defined by the election organiser.
- The proposers use the standard proposer declaration with a mandatory name and optional contact
- information and job title. Again, additional information can be required.

- 782 If a party is being nominated, the primary proposer will be the contact. Information on candidates in a party list can also be provided.
- Candidates, either individuals or on a party list, must define the action being taken and may provide
- scrutiny information. The scrutiny requirements indicate how the candidate has met any conditions for
- 786 standing in this election. This could include indicating that a deposit has been paid or providing a
- 787 reference to prove that he or she lives in the appropriate area. This information can be signed
- 788 independently of the complete message.

### Response to Nomination (220)

- This message is sent from the election organiser to the candidate or nomination authority for a party to
- 791 say whether the nomination has been accepted. Along with the acceptance information and the basic
- 792 information of election, contest and party and candidate names, the candidate's contact details and
- affiliation can be included and a remark explaining the decision.

#### 794 Additional Rules

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| Error Code | Error Description  |
|------------|--|
| 3220-001   | If the nomination has not been accepted, a reason for rejection is required in the |
|            | Remark element   |

#### 795 Candidate List (230)

- This schema is used for messages transferring candidate lists for specified contests. It has the election
- event, election and contest identifiers, and optionally the event dates and a contest description. The list
- 798 itself can be either a list of candidates, each with a name, address, optional affiliation and other useful
- 799 data, or a list of parties. In the latter case, contact information and a list of candidates under a party list
- 800 system can also be included.

#### Voter Registration (310)

- 802 This schema is used for messages registering voters. It uses the VoterIdentificationStructure.
- 803 The VoterInformationStructure is used unchanged. Proof of ID can be provided.
- There is the facility for the transmission channel (for example a trusted web site) to add the time of
- 805 transmission.

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#### 806 Additional Rules

| Error Code | Error Description                                   |
|------------|---|
| 3310-001   | The Proxy must not have a VToken or VTokenQualified |

#### Election List (330)

- This schema is primarily used for messages communicating the list of eligible voters for an election or set
- of elections. It can also be used for any other purpose that involves the transfer of voter information.
- Partial lists are allowed through the use of the Qualifier, Blocked and VoterGroup elements. So, for
- 811 example, a list of postal voters or a list of proxies can be produced. The schema can also be used for
- 812 filtered lists such as a list of postal proxies. These lists sometimes do not contain any names meeting the
- filter so empty lists are allowed.

814 For each voter, information is provided about the voter himself or herself, and optionally about the 815 elections and contests in which the voter can participate. The information about the voter is the same as 816 that defined in the 310-voterregistration schema. Added to this can be a list of elections, each identifying 817 the election and the contest in which this voter is eligible to vote, and the polling places available. Any voter can have a Blocked element set against them with an optional Reason and Channel. This allows a 818 list to be produced for a polling place indicating those that have already voted by another means or who 819 have registered for a postal vote. It can also be used if the complete electoral register must be transmitted 820 821 (perhaps as a fraud prevention measure) but some people on the register are no longer eligible to vote.

#### **Additional Rules** 822

| Error Code Error Description |   |  |  |  |
|------------------------------|---|--|--|--|
| 3330-002                     | The polling district can only be included for either the voter or the election. |  |  |  |
| 3330-003                     | The polling place can only be included for either the voter or the election.    |  |  |  |

### Polling Information (340)

- 824 The polling information message defined by this schema is sent to a voter to provide details of how to 825 vote. It can also be sent to a distributor, so multiple sets of information are allowed. In the case of SMS 826 voting, ballot information may also be required, so this can be included. Either one or several sets of 827 polling information may be sent to each voter for any election event.
- 828 Some information about the voter and any proxy may be included, for example to print on a polling card. 829 This can also include a mailing address for a distributor to use.
- 830 Information about the elections and contests is included for the benefit of the voter. For each voting 831 channel, this includes where to vote (which could be a polling station, address for postal voting, URL for Internet voting, phone number for SMS voting etc) and the times that votes can be placed. Use of the 832 DisplayOrder attribute on these allows the display or printing of information to be tailored from within the 833
- 834 XML message.

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- 835 Ballot information may be included if required. This is a subset of the information defined in the 410ballots schema. In this case, it is likely that the short code for a candidate will be used for SMS voting. It is 836
- 837 possible that an expected response code will be provided as well. Both the short code and expected
- 838 response code may be tailored to the individual voter as part of a security mechanism.

## **Outgoing Generic Communication (350a)**

- 840 This schema provides a common structure for communications to the voter. Individual message types can be designed based on extensions of this schema. 841
- 842 The voter must always provide a name and might provide one or more identifiers. These are shown as a 843 restriction of the VoterIdentificationStructure, the restriction being to leave out the VToken and
- 844 VTokenQualified. Contact details are also required, and it is expected that at least one of the allowed
- 845 contact methods will be included. Inclusion of proxy information is optional.
- The identifiers for the election event, election and contest are optional. There is then an element in which 846 847 a message can be placed in any of several different formats according to the channel being used.

# **Incoming Generic Communication (350b)**

849 This schema provides a common structure for communications from the voter. Individual message types 850 can be designed based on extensions of this schema.

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| 851 The voter's name must be provided and there can be one or more identifiers. I | These are snow | n as a |
|---|----------------|--------|
|---|----------------|--------|

- 852 restriction of the VoterIdentificationStructure, the restriction being to leave out the VToken and
- 853 VTokenOualified. Contact details are also required, and it is expected that at least one of the allowed
- 854 contact methods will be included. Inclusion of proxy information is optional.
- 855 The identifiers for the election event, election and contest are optional. There is then an element in which
- 856 a message can be placed in any of several different formats according to the channel being used.

#### Internal Generic (350c) 857

- 858 This schema provides a common structure for communications between those involved in organizing an
- election. Individual message types can be designed based on extensions of this schema. 859
- 860 There are optional To and From elements, which can contain any EML elements. It is expected that
- 861 these will usually be a responsible officer or a person's name and contact information.
- The identifiers for the election event, election and contest are optional. There is then an element in which 862
- a message can be placed in any of several different formats according to the channel being used. 863

#### 864 **Outgoing Channel Options (360a)**

- 865 This schema is used for messages offering a set of voting channels to the voter. It is an extension of
- schema 350a. A message conforming to this schema will include a list of allowed channels, either to 866
- request general preferences or for a specific election event or election within the event. 867

### **Incoming Channel Options (360b)**

- 869 This schema is used for messages indicating one or more preferred voting channels. It may be sent in
- 870 response to 360a or as an unsolicited message if this is supported within the relevant jurisdiction.
- 871 It is an extension of schema 350b, and indicates preferred voting channels in order of preference.

#### 872 **Ballots (410)**

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- 873 This schema is used for messages presenting the ballot to the voter or providing a distributor with the
- information required to print or display multiple ballots. 874
- 875 In the simplest case, a distributor can be sent information about the election event and a ballot ID to
- 876 indicate the ballot to print.
- In other cases, the full information about the elections will be sent with either an election rule ID to identify 877
- 878 the voters to whom that election applies or a set of voter names and contact information. If the ballot is
- being sent directly to the voter, this information is not required. Since printed ballot papers are likely to 879
- 880 require a unique identifier printed on them, the range to be used for each ballot type can be defined.
- 881 The election information starts with the election identifier and description. This is followed by information
- 882 related to the contest and any other messages and information required. Note that each voter can only
- 883 vote in a single contest per election, so only a single iteration of the Contest element is required.
- 884 A contest must have its identifier and a list of choices for which the voter can vote. A voter can vote for a
- candidate, an affiliation (possibly with a list of candidates) or a referendum proposal. There is also a set of 885
- optional information that will be required in some circumstances. Some of this is for display to the voter 886
- 887 (HowToVote and Messages) and some controls the ballot and voting process (Rotation,
- 888 VotingMethod, MaxVotes, MinVotes, MaxWriteIn).

#### **Authentication (420)**

- 890 The authentication message defined by this schema may be used to authenticate a user during the voting
- 891 process. Depending on the type of election, a voter's authentication may be required. The precise
- 892 mechanism used may be channel and implementation specific, and can be indicated using the

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LoginMethod element. In some public elections the voter must be anonymous; in which case the prime method used for authentication is the voting token. The voting token can contain the information required to authenticate the voter's right to vote in a specific election or contest, without revealing the identity of the person voting. Either the VToken or the VTokenQualified must always be present in an authenticated message. The VotingChannel identifies the channel by which the voter has been authenticated.

## **Authentication Response (430)**

The authentication response is a response to message 420. It indicates whether authentication succeeded using the Authenticated element, and might also present the ballot to the user. This is a restriction of the Ballots element to allow only a single ballot per reply.

### 902 Cast Vote (440)

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- This message represents a cast vote, which comprises an optional voting token (which may be qualified) to ensure that the vote is being cast by an authorized voter, information about the election event, each election within the event and the vote or votes being cast in each election, an optional reference to the ballot used, the identifier of the reporting unit if applicable and a set of optional audit information.
- For each election, the contest is identified, with a set of, possibly sealed, votes. The votes are sealed at this level if there is a chance that the message will be divided, for example so that votes in different elections can be counted in different locations.
- The selection of candidates, affiliations or a referendum option uses the Selection element. If an election requires preferences to be expressed between candidates, multiple Selection elements will be
- 912 used, each of these having a suitable Value attribute. Some elections allow write-in candidates, and
- 913 these are handled in a similar way. Preferences can also be expressed between parties, using the
- 914 Affiliation element. The PersonalIdentifier is used in elections where each voter is given an
- 915 individual list of codes to indicate their selection.
- A more complex election might request the voter to vote for a party, then express a preferences of
- 917 candidates within the party. In this case, the Affiliation element is used to indicate the party
- 918 selected, and multiple Candidate Identifier elements, each with a Value attribute are used to
- 919 express candidate preferences.
- 920 Preferences in a referendum are handled in the same way as they are for candidates and parties, using
- 921 the ReferendumOptionIdentifier.

### 922 Retrieve Vote (445)

- 923 This message is used for voting systems that include a pre-ballot box from which votes can be retrieved
- 924 and amended before being counted. When a vote is retrieved, it should be deleted from the pre-ballot
- 925 box.

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## **Vote Confirmation (450)**

- The vote confirmation message can be used to show whether a vote has been accepted and provide a
- 928 reference number in case of future queries. Some voting mechanisms require multiple
- 929 ConfirmationReference elements. If the vote is rejected, the Remark element can be used to show a
- 930 reason.

#### Votes (460)

- 932 This schema is used to define a message comprising a set of votes being transferred for counting. It is a
- 933 set of CastVote elements from schema 440 with the addition of the ProposedRejection and
- 934 ProposedUncounted elements and audit information for the voting system. If a vote is rejected, for
- example, because a voter has chosen to spoil a ballot paper, many authorities will want to count that vote

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- as having been cast. The UncountedVotes element is reserved for those cases where that record is not required, for example when the result is thought to be fraudulent. A ProposedRejection or
- 938 ProposedUncounted element must have a ReasonCode attribute, and may have a Reason attribute to
- 939 describe the code. They may also have an Objection attribute. This indicates that someone has
- objected to this vote being rejected or the proposal that it should not be counted.

#### VToken Log (470)

- The message defined by this schema is used to add voting tokens (which may be qualified) to an audit
- 943 log. The VToken or VTokenQualified is extended by the addition of a Status attribute with a value of
- voted or unvoted for the VToken and voted, unvoted and withdrawn for the VTokenQualified. In
- addition to sending single tokens as they are used, the schema can be used to validate a message
- 946 sending multiple tokens optionally grouped by voting channel. This might be used instead of sending
- 947 tokens as they used or, for example, to send the unused tokens at the end of an election. The Update
- 948 element can be used to indicate that an existing log is being updated rather than the message containing
- a complete new log. The logging system can also be identified for audit purposes.

### Audit Log (480)

- The message defined by this schema is used to log the use of each seal with associated information for
- 952 audit purposes.
- 953 An audit log message can be transmitted individually as the message causing the log entry is sent or
- 954 received, or the logs can be stored, and several seals logged at once. Ideally, every device that can
- 955 create or consume a message will create a log entry so that pairs of entries can be matched. The most
- 956 important messages to log are those associated with the voting process itself, and these are shown
- 957 below.

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958 When used in this message, the Response element will not have an AuditInformation child.

| Originating<br>Device                 | Gateway  | Voting<br>System   | Counting<br>System | Vtoken<br>Logging<br>System | Seal<br>Logging<br>System | Other              | Notes |
|---------------------------------------|----------|--------------------|--------------------|-----------------------------|---------------------------|--------------------|-------|
| 130                                   |          |                    |                    |                             |                           |                    | 4     |
| 410 next receiver                     | receiver | sender<br>receiver |                    |                             |                           |                    |       |
| 420 previous sender 430 next receiver | receiver | sender             |                    |                             |                           | sender / receiver  | 3     |
| 440 previous sender                   |          | receiver           |                    |                             |                           | 0011001 / 10001101 | Ü     |
| 445 previous sender                   |          | receiver           |                    |                             |                           |                    |       |
| 450 next receiver                     | receiver | sender             |                    |                             |                           |                    |       |
| 460                                   |          | sender             | receiver           |                             |                           |                    |       |
| 470                                   |          | sender             | sender             | receiver                    |                           | sender             |       |
| 480 sender                            | sender   | sender             | sender             | sender                      | receiver                  | sender             | 2     |
| 510                                   |          |                    | sender             |                             |                           | receiver           |       |
| 520                                   |          |                    | sender             |                             |                           | sender / receiver  |       |

#### Notes:

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- **1.** In some cases (e.g. a kiosk) there may be no gateway involved. In this case, the values in the Gateway column apply to the Originating Device.
- 2. Creators and receivers of 480 (audit log) messages may not be required to log the seals. In particlar, if an adit log message is sent per seal created or received, the seal on the 480 message must not be logged.
- **3** "Other" may be the sender when the message is sent to a printer. In this case, the receiver will also be an "Other".
- **4.** An audit log should only be created when the message is used to communicate an error. Most devices can send or receive 130 messages.

The message may contain the name and ID of the event, election and contest. It can also indicate whether this is an update to an existing log or a new log. Following the logged seals, a text message can be added as well as audit information for the audit logging message itself.

Each seal being logged must indicate whether the device sending the log was the sender or receiver of the sealed message. It may be accompanied by the voting token associated with the seal and possibly additional audit information. This will be the audit information from the message being logged with additional information about the message. Most of this is common to all message types, but some message types require specific audit information. One of these is the 130-response message. When this is used to convey an error, almost the complete message payload (the Response element and its contents apart from the audit information) is logged with the usual message-independent data.

### **Count (510)**

The count message defined by this schema is used to communicate the results of one or more contests that make up one or more elections within an election event. It may also be used to communicate the count of a single reporting unit for amalgamation into a complete count.

- The message includes the election event identifier, and for each election, the election identifier, an optional reference to the election rule being used and information concerning the set of contests.
- In some cases, reporting for a contest may be required at a lower level (for example, for each county in a state). For this reason, reporting may be done at the level of the reporting unit, the total votes, or for a total vote and the breakdown according to the multiple reporting units.
- 980 Each contest indicates its identifier, and optionally the counting system and the maximum number of votes that each voter could cast. The key information is that about the votes cast for each of the choices 981 available and the numbers of abstentions and rejected and uncounted votes. If a vote is rejected, for 982 example, because a voter has chosen to spoil a ballot paper, many authorities will want to count that vote 983 as having been cast. The UncountedVotes element is reserved for those cases where that record is not 984 required, for example when the result is thought to be fraudulent. Both the UncountedVotes and 985 986 RejectedVotes elements have Reason (optional) and ReasonCode (mandatory) attributes to indicate why the votes were treated as they have been. The former is a textual description, and the latter a code. 987
- 988 For each choice available to the voter, the identifier and number of valid votes are mandatory. The other 989 information provided depends on the type of election. For example, the Value attribute of the Selection 990 element can be used to indicate whether a candidate was a first or second choice in an election run under 991 the single transferable vote system. In the simplest cases, the identifier for the candidate (perhaps with 992 the party), the party or the referendum option is given. If the voter was able to vote for a party and provide a preference for candidates within the party, the AffiliationIdentifier element is used, and multiple 993 CandidateIdentifier elements may be used, each with a Count attribute. This count is the result of 994 995 whatever algorithm has been used to calculate the ranking of the candidates.
- This schema allows for Simulation and Extrapolation of Counts and subsequently Results. Simulation being the facility to forecast the result of a contest based on the result of another contest. Extrapolation is the facility to forecast the final result of a contest based on the count so far.

#### **Result (520)**

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- Messages described by this schema can be used to communicate the results of simple election types.
- One specific use is to provide an input into the calculation algorithm for elections using the additional member system.
- 1003 The main part of the schema is held within the Selection element. This allows a choice of candidate,
- affiliation or referendum option identifiers to be defined with the position that choice achieved (first,
- second etc). Optionally, the number of votes can be shown. A candidate can be associated with his or her
- affiliation if required. Write in candidates will be shown in the same way as other candidates, although
- they will only have an Id attribute if this is assigned in the election system after the votes are cast.
- This schema allows for Simulation and Extrapolation of Results using data from Counts. Simulation being the facility to forecast the result of a contest based on the result of another contest. Extrapolation is the
- 1010 facility to forecast the final result of a contest based on the count so far.

## Statistics (530)

- This schema allows for a variety of statistical information to be made available about the counts and
- 1013 results captured in the Counts 510 schema. For example statistics about attendance and votes at each
- district and county level or by which voting channels have been used.

- The statistics can be made available through any type of outlet be it Web, TV, SMS etc. and to any type of organization eg news agencies, political parties.
- 1017 **Options Nomination (610)**
- This schema is used to submit proposals, for example for a referendum or company AGM. It uses the generic Proposal element to define the proposal itself. One of more proposers can be named and may
- sign the nomination.
- 1021 Options Nomination Response (620)
- This message is sent from the election organiser to the proposer to say whether the nomination has been
- accepted. Along with the acceptance information and the basic information of election, contest and
- identifier for the proposal, a remark can be made explaining the decision.

#### 1025 Additional Rules

| Error Code | or Code Error Description   |  |  |
|------------|---|--|--|
| 13670-001  | If the nomination has not been accepted, a reason for rejection is required in the Remark element |  |  |

#### 1026 **Options List (630)**

- This schema is used for messages transferring lists of proposals for a referendum. It may identify the election event, and provides details about the election. Each proposal in a referendum counts as an election, so each election identified will hold a single proposal.
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## 6. Conformance

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To conform to this specification, a system must implement all parts of this specification that are relevant to the interfaces for which conformance is claimed. The required schema set will normally be part of the conformance criteria and should indicate schema version numbers. For example, the specification for an election list system might specify that a conforming system must accept and generate XML messages conforming to the following illustrative capability matrix:

| Schema | Accept     | Generate |
|--------|------------|----------|
| EML110 | V5.0, V6.0 |          |
| EML310 | V5.0, V6.0 |          |
| EML330 |            | V6.0     |
| EML340 |            | V6.0     |
| EML350 |            | V6.0     |
| EML360 |            | V6.0     |

1037 A conforming system will then conform to the relevant parts of the EML specification and the accompanying schemas.

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## **B.** Other Considerations

### 1056 **B.1 Security**

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- This section presents a general discussion of many of the security considerations commonly found in many election environments. As presented previously, these standards apply at EML interface points and define data security mechanisms at such interface points. This document is not intended to provide a complete description, nor a set of requirements for, secure election systems. In fact, the data security mechanisms described in this document are all optional, enabling compliance with these standards
- 1062 without regard for system security at all.
- This discussion is included here simply to show how the information passed through the various
- 1064 interfaces described in these standards could be secured and used to help meet some of the
- 1065 requirements commonly found in some elections scenarios.

#### **Basic Security Requirements**

- The security governing an election starts before the actual vote casting. It is not only a matter of securing the location where the votes are stored. An intensive analysis into security related concerns and possible
- threats that could in one way or another affect the election event resulted in the following:
- Security considerations of e-voting systems include:
- 1071 Authentication
- 1072 Privacy/Confidentiality
- 1073 Integrity
- 1074 Non-repudiation

#### 1075 Authentication

- This is checking the truth of a claim of identity or right to vote. It aims to answer questions such as "Who are you and do you have the right to vote?"
- 1078 There are two aspects of authentication in e-voting systems:
- 1079 Checking a claim of identity
- 1080 Checking a right to vote.
- In some e-voting scenarios the two aspects of authentication, checking a claim of identity and checking a right to vote, may be closely linked. Having checked the identity of the voter, a list of authorized voters may be used to check the right to vote.
- In other scenarios the voter's identity must remain private and must not be revealed by a ballot. In which case some systems may provide a clear separation between checking of the claim of identity, which may be done some time before the ballot takes place, from checking the right to vote at the time of the vote is cast. Alternatively, other mechanism may be used to ensure the privacy of the voter's identity on cast votes (i.e. by anonymizing the ballot).
- In the physical voting world, authentication of identity is made by using verifiable characteristics of the voter like handwritten signatures, address, etc and physical evidence like physical IDs; driver's license,
- 1091 employee ID, Passport etc, all of this can be termed a physical 'credential'. This is often done at the time
- 1092 an electoral register is set up, which can be well before the actual ballot takes place.
- 1093 Checking the authenticity of the right to vote may be performed at various stages in the process. Initial authenticity checks may be done related to the voter's identity during registration.

- 1095 Where an election scenario demands anonymity of the voter and privacy of the voter's ballot, the identity
- 1096 of the voter and the cast votes must be separated at some time within the voting process. This can be
- 1097 done in several ways by a voting system including, but not restricted to, the following options:
- Authentication of the right to vote by itself does not reveal a voter's identity, but does verify he has a
- 1099 legitimate right to vote (e.g. the VToken data provides authentication of the right to vote but has
- anonymous properties as to the identification of the person voting).
- 1101 An voter's identity and the right to vote are both validated (i.e. the VToken data has both 'voter
- 1102 identification and 'right to vote' authentication properties) and then the cast votes are clearly separated
- from the identity of the voter (i.e. the voters identification occurs before the ballot is 'anonymized')
- 1104 In all cases any verification of the authenticity that takes place after the voter has indicated his/her
- 1105 choices must preserve the privacy of those choices according to the laws of the jurisdiction and the
- 1106 election rules.

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- 1107 Finally, when counting and auditing votes it is necessary to be able to check that the votes were placed
- by those whose right to vote has been authenticated.
- 1109 Public democratic elections in particular will place specific demands on the trust and quality of the
- 1110 authentication data. Because of this and because different implementations will use different mechanisms
- 1111 to provide the voter credential, precise mechanisms are outside the scope of this document.

#### Privacy/Confidentiality

- 1113 This is concerned with ensuring information about voters and how votes are cast is not revealed except
- as necessary to count and audit the votes. In most cases, it must not be possible to find out how a
- particular voter voted. Also, before an election is completed, it should not be possible to obtain a count of
- 1116 how votes are being cast.
- 1117 Where the user is remote from the voting system then there is a danger of voting information being
- 1118 revealed to someone listening in to the communications. This is commonly stopped by encrypting data as
- 1119 it passes over the communications network.
- The other major threat to the confidentiality of votes is within the system that is collecting votes. It should
- 1121 not be possible for malicious software that can collect votes to infiltrate the voting system. Risks of
- 1122 malicious software may be reduced by physical controls, careful audit of the system operation and other
- means of protecting the voting systems.
- 1124 Furthermore, the results of voting should not be accessible until the election is complete. Potential
- approaches to meeting this goal might include access control mechanisms, very careful procedural
- 1126 control over the voting system, and various methods of protecting the election data using encryption
- 1127 techniques.

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#### Integrity

- 1129 This is concerned with ensuring that ballot options and votes are correct and unaltered. Having
- established the choices within a particular ballot and the voter community to which these choices apply,
- the correct ballot information must be presented to each voter. Also, when a vote is placed it is important
- that the vote is kept correctly until required for counting and auditing purposes.
- 1133 Using authentication check codes on information being sent to and from a remote voter's terminal over a
- 1134 communications network generally protects against attacks on the integrity of ballot information and
- votes. Integrity of the ballot and voting information held within computer systems may be protected to a
- 1136 degree by physical controls and careful audit of the system operation. However, much greater confidence
- 1137 in the integrity of voting information can be achieved by using digital signatures or some similar
- 1138 cryptographic protection to "seal" the data.
- 1139 The fundamental challenge to be met is one of maintaining voter privacy and maintaining the integrity of
- 1140 the ballot.

#### **Non-Repudiation**

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- 1142 Non-repudiation is a derivative of the identification problem. Identification in e-voting requires that the
- 1143 system provide some level of assurance that the persons representing themselves as valid participants
- 1144 (voters, election workers, etc.) are, in fact, who they claim to be. Non-repudiation requires that the system
- provides some level of assurance that the identified participant is not able to successfully assert that the 1145
- actions attributed to them via the identification mechanism were, in fact, performed by someone else. The 1146
- 1147 two requirements are related in that a system with a perfect identification mechanism and undisputable
- 1148 proof of all actions would leave no room for successful repudiation claims.
- 1149 Non-repudiation also requires that the system provide assurance that data or actions properly associated
- 1150 with an identified participant can be shown to have remained unaltered once submitted or performed. For
- example, approved candidate lists should be verified as having come from an authorized election worker, 1151
- 1152 and voted ballots from a valid voter. In both cases the system should also provide a way to ensure that
- 1153 the data has remained unchanged since the participant prepared it.
- 1154 Non-repudiation is not only a technical quality of the system. It also requires a certain amount of pure
- 1155 policy, depending on the technology selected. For example, in a digital signature environment, signed
- data can be very reliably attributed to the holder of the private key(s), and can be shown to be 1156
- subsequently unmodified. The policy behind the acceptance of these properties, however, must be very 1157
- clear about the responsibilities of the private key holders and the required procedures for reporting lost or 1158
- stolen private keys. Further, and especially in "mixed-mode" elections (where voters can chose between 1159
- 1160 multiple methods of voting), it may often be desirable to introduce trusted time stamps into the election
- 1161 data stream, which could be used to help determine acceptance criteria between ballots, or help resolve
- 1162 issues with respect to the relative occurrence of particular events (e.g. ballot cast and lost keys reported).
- 1163 The presence of the time information itself would not necessarily enable automatic resolution of these
- 1164 types of issues, but by providing a clear ordering of events could provide data that can be fed into
- 1165 decisions to be made according to established election policy.

#### 1166 **Terms**

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- 1167 The following security terms are used in this document:
- 1168 Identity Authentication: the means by which a voter registration system checks the validity of the 1169 claimed identity.
- 1170 Right to vote authentication: the means by which the voting system checks the validity of a voter's 1171 right to vote.
- 1172 VToken: the means by which a voter proves to an e-voting system that he/she has the right to vote in 1173
- 1174 VToken Qualified: the means by which a VToken can be qualified. The reason for the qualification is always appended to a VToken that is qualified. For example, a qualified VToken may be issued to a 1175 challenged voter. 1176
- 1177 Vote sealing: the means by which the integrity of voting data (ballot choices, vote cast against a given VToken) can be protected (e.g. using a digital signature or other authentication code) so that it can be 1178 proved that a voter's authentication and one or more votes are related. 1179

#### **Specific Security Requirements**

- 1181 Electronic voting systems have some very specific security requirements that include:
- 1182 Only legitimate voters are allowed to vote (i.e. voters must be authenticated as having the right to 1183 cast a vote)
- 1184 Only one set of choices is allowed per voter, per contest
- 1185 The vote cannot be altered from the voter's intention
- 1186 The vote may not be observed until the proper time

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- 1187 The voting system must be accountable and auditable
- Information used to authenticate the voter or his/her right to vote should be protected against misuse (e.g. passwords should be protected from copying)
- Voter privacy must be maintained according to the laws of the election jurisdiction. (Legal requirements of public elections in various countries conflict. Some countries require that the vote cannot be tracked back to the voter's identity, while others mandate that it must be possible to track every vote to a legitimate voter's identity)
- The casting options available to the voter must be genuine
- Proof that all genuine votes have been accurately counted.
- There are some specific complications that arise with respect to security and electronic voting that include:
- Several technologies may be employed in the voting environment
- The voting environment may be made up of systems from multiple vendors
- A voter may have the option to vote through alternative delivery channels (i.e. physically presenting themselves at a poling station, by post, by electronic means)
- The voting systems need to be able to meet various national legal requirements and local voting rules for both private and public elections
- Need to verify that all votes are recorded properly without having access to the original input
- The mechanism used for voter authentication may vary depending on legal requirements of the contest, the voter registration and the e-voting systems for private and public elections
- The user may be voting from an insecure environment (e.g. a PC with no anti-virus checking or user access controls).
- 1209 In addition, the objectives of security architectures for electronic voting systems should include:
- 1210 Being open
- Not restricting the authentication mechanisms provided by e-voting systems
- Specifying the security characteristic required of an implementation, allowing for freedom in its precise implementation.
- Providing the means to exercise security isolation and controls at interfaces between various election processes, thereby providing the ability to implement isolated trusted logic processes to meet dedicated functions of an election service. Process security isolation ensures that one voting subprocess does not inadvertently effect another voting sub-process thereby undermining the whole voting system.

#### 1219 Security Architecture

- The architecture proposed here is designed to meet the security requirements and objectives detailed above, allowing for the security complications of e-voting systems listed.
- 1222 The architecture is illustrated in figure 3a below, and consists of distinct areas:
- 1223 Voter identification and registration
- 1224 Right to vote authentication
- Protecting exchanges with remote voters
- Validating Right to Vote and contest vote sealing
- Vote confidentiality.
- 1228 Candidate list Integrity

1229 Vote counting accuracy

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1230 Voting system security controls.

#### Voter identification and registration

- 1232 The Voter identification and registration is used to identify an entity (e.g. person) for the purpose of 1233 registering the person has a right to vote in one or more contests, thus identifying legitimate voters. The 1234 security characteristics for voter identification are to be able to authenticate the identity of the legal person 1235 allowed to vote in a contest and to authenticate each person's voting rights. The precise method of voter 1236 identification is not defined here, as it will be specific to particular voting environments, and designed to meet specific legal requirements, private or public election and contest rules. The voter registration 1237 system may interact with the e-voting system and other systems to define how to authenticate a voter for
- 1238 1239 a particular contest.
- 1240 Voter identification and registration ensures that only legitimate voters are allowed to register for voting.
- 1241 Successful voter registration will eventually result in legitimate voters being given a means of proving their
- right to vote to the voting system in a contest. Depending on national requirements or specific voting 1242
- 1243 rules/bylaws the voter may or may not need to be anonymous. If the voter is to be anonymous, then there
- 1244 must not be a way of identifying a person by the means used to authenticate a right to vote to the e-voting
- 1245 system. Right to vote authentication is the means of ensuring a person has the right to cast a vote, but it
- 1246 is not the identification of the person.

#### Right to vote authentication

- 1248 Proof of the right to vote is done by means of the VToken, which is generated for the purpose of
- 1249 authentication that the voter has a legitimate right to vote in a particular contest.
- 1250 The security characteristic of the VToken and hence its precise contents may vary depend on the precise
- 1251 requirements of a contest, the supplier of the voter registration system, the e-voting system, the voting
- 1252 channel or other parts of the electoral environment. Thus, the content of the VToken will vary to
- 1253 accommodate a range of authentication mechanisms that could be used, including; pin and password,
- 1254 encoded or cryptographic based password, hardware tokens, digital signatures, etc.
- 1255 The contents of the VToken may also depend on the requirements of a particular contest, which may
- 1256 mandate a particular method be used to identify the person and the voter. For example, if a country has a
- 1257 national identity card system, it could be used for the dual purpose of identifying the person and providing
- 1258 proof that the person is entitled to vote, provided the legal system (or the voting rules of a private election)
- 1259 allow a personal identity to be associated with a vote. However, this would not work for countries or
- 1260 private voting scenarios that require the voter to be anonymous. For such a contest the mechanism used
- 1261 to identify that a person has the right to cast a vote must not reveal the identity of the actual person, thus
- 1262 under such voting rules voter identity authentication and right to vote authentication do not use the same
- 1263 information or semantics.
- 1264 The security characteristic required of the VToken may also vary depending on legal requirements of a
- 1265 country or electoral rules used in a particular contest. Also, the threats to misuse of VTokens will depend
- 1266 to a large degree on the voting channels used (e.g. physical presence at voting station, Internet, mobile
- 1267 phone). Bearing this in mind the XML schema of the VToken components must allow for various data
- 1268 types of authentication information to be contained within it.
- 1269 It must be possible to prove that a VToken is associated with a vote cast and the rules of the contest are
- 1270 followed, such as only one vote being allowed per voter, per contest. Thus providing proof /non-
- 1271 repudiation that all votes were genuine, they were cast in accordance with the rules of the contest, that no vote has been altered in any way and that all the votes counted in a contest were valid when audited. 1272
- 1273 Depending on the legal requirements of a country or electoral rules a voter may be challenged as to the
- 1274 right to vote, or may be given a temporary right to vote. In such cases the VToken may need to be
- qualified with a reason. In this document this is called a VToken Qualified. Before a vote is considered 1275

1276 legitimate and counted the reason for the qualification must have been suitably scrutinized, which could 1277 be done by the voting officials.

#### Protecting exchanges with remote voters

- The VToken may be generated as part of the registration system, the e-voting system, or as interaction between various components of a voting environment, as illustrate in Figure 3a. The VToken will need to
- 1281 be provided securely to the voter so that this can be used to prove the right to vote.
- 1282 The exchange of information when casting a vote must be protected by secure channels to ensure the
- 1283 confidentiality, integrity of voting data (VToken(s) and vote(s) cast) and that this is correctly delivered to
- the authenticated e-voting system. If the channel isn't inherently secure then this will require additional
- 1285 protection using other mechanisms. Possible mechanisms might include: a postal system with sealed
- 1286 envelopes, dedicated phone channel, secure e-mail, secure internet link (SSL), peer to peer server/client
- 1287 authentication and a seal.

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- 1288 Wherever technically possible the exchange of information should be secured and integrity guaranteed
- even if non-secure communications channels are used.

#### Validation right to vote and contest vote sealing

- 1291 When a vote is cast, to ensure that it cannot be altered from the voter's intention, all the information used
- to authenticate the right to vote and define the vote cast must be sealed to ensure the integrity and non-
- 1293 repudiability of the vote. This seal may be implemented using several mechanisms ranging from digital
- 1294 signatures (XML and CMS), cryptographic seals, trusted timestamps and other undefined mechanisms.
- 1295 The seal provides the following security functions:
- The vote cannot be altered from the voter's intention
- The voting system is accountable and auditable.
- The right to vote may be validated at the time the vote was cast. If votes are not checked for validity
- 1299 before sealing then the right to vote must be validated at the time that votes are subsequently counted.
- Also when counting, or otherwise checking votes, the validity of the seal must be checked.
- 1301 If votes are sealed and recorded without being checked for validity at the time they were cast, then the
- time that the vote was cast must be included in the seal, so that they may be checked for validity before
- they are counted.
- 1304 In some election scenarios it is required to audit a vote cast to a particular voter, in this case a record is
- also needed of the allocation of a VToken to a voter's identity. Such systems also provide non-repudiation
- of the voter's actions. In such cases a voter cannot claim to have not voted or to have voted a different
- way, or that his vote was not counted. In many election scenarios where this type of auditing is required, it
- must not be easy to associate a VToken to the Voter's identity, therefore this type of records must be
- under strict control and protected by security mechanism and procedures, such as; encryption, key
- 1310 escrow and security operating procedures.

#### Vote Confidentiality

- 1312 All cast votes must not be observed until the proper time, this requires confidentiality of the vote over the
- 1313 voting period, how this is achieved will vary from e-voting system to e-voting system. Mechanism of vote
- 1314 confidentiality, range from trust in the e-voting systems internal security functions (processes and
- mechanisms) to encryption of the data, with key escrow tools.

#### Candidate List integrity

- To ensure that the voter is present and that the candidate list is genuine, there must be a secure channel
- between the voting system and the person voting or the data must be sealed. The approach selected
- 1319 must ensure that there is no man-in-the-middle that can change a vote from what the voter intended.
- 1320 There are various ways this requirement can be met, ranging from the candidate list having unpredictable

- 1321 characteristics with a trusted path to convey that information to the voter, to trust placed in the complete ballot/vote delivery channel.
- As an example, there may be a secure path to convey the VToken to the person entitled to vote, a way of
- ensuring that a voter is always presented with a genuine list of candidates might be to encode the
- 1325 candidate list as part of a sealed VToken.
- 1326 In summary, there must be a way of ensuring the validity of the ballot options and voter selection.

#### Vote counting accuracy

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Audit of the system must be able to prove that all vote casts were genuine and that all genuine votes were included within the vote count. Voters may need to be able to exercise that proof should they so desire. Thus auditing needs data that has non-repudiation characteristics, such as the VToken/vote sealing, see schema 470 and 480.

### Voting System Security

The overall operation of the voting systems and its physical environment must be secure. Appropriate procedural, physical and computing system controls must be in place to ensure that risks to the e-voting systems are met. There must be a documented security policy based upon a risk analysis, which identifies the security objectives and necessary security controls.

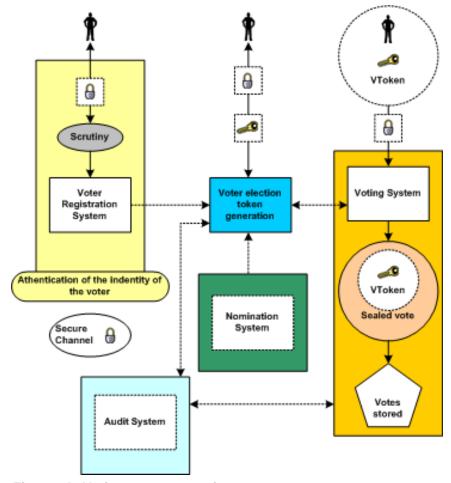


Figure 3A: Voting system security

#### Remote voting security concerns

Many new election systems are currently under evaluation. These systems tend to offer deployment options in which the communication between the voter and the election officials is carried out in an environment that is not completely under the control and monitoring of the election officials and/or election observers (e.g., the Internet, private network, telephones, cable TV networks, etc.). In these 'remote' or 'unattended' environments, several particular security concerns and questions like:

- How do I know that that the candidate information I am being presented with is the correct information?
- How do I know that my vote will be recorded properly?
- How do I know there isn't a man-in-the-middle who is going to alter my vote when I place it?
- How do I know that it is the genuine e-voting server I'm connected to that will record my vote rather than one impersonating it that's just going to throw my vote away?
  - How do I know that some component of the system does not have malicious software which will attempt to alter the ballot choices as represented to me or alter my election?

The type and importance of a particular contest will have an effect on whether the above concerns exist and whether they do, or do not, represent a tangible threat to the voting process and its outcome. The table listed at Appendix B2 shows the concerns that have been identified as possibilities for one such remote or unattended environment (the Internet) that could be used in public election voting scenarios. The table shows how the concerns can be translated to technical threats and characterizes security services that may be used to counter such threats. Many of the items are not unique to the Internet, and can serve as a useful reference or starting point in developing similar threat analysis for other digital and/or unattended voting environments. How the security services are implemented in any particular environment or deployment is outside the scope of this document allowing freedom to the system providers.

# **B.2 Internet Voting Security Concerns**

| Concerns raised on Internet voting |   | Resulting Technical Threats   | Possible generic security service countermeasure   |
|------------------------------------|---|---|--|
| 1.                                 | Impersonation of the right to vote.                               | Inadequate, incorrect or improper identification of person during registration of | Trusted voter identification and registration using:   |
|                                    | The concern here is that a person attempts to impersonate to be a | voters  | Security Procedures.   |
|                                    | legitimate voter when he/she is not.                              |   | Best Practices.  Secure communications   |
|                                    |   |   | channels.  |
|                                    | The initial task of verifying that a person has the right to      |   |  |
|                                    | vote must be part of the voter registration process.              |   | The voter registration authority must follow standard Security Operating Procedures (SOPs) which |
|                                    |   |   | ensure due diligence has been done.  |

|   | A person must not be given the right to vote until after proper due diligence has been undertaken during voter registration that the person has a right to vote in a contest. | Inadequate privacy of the exchange between the person and the electoral system during voter registration | Channel between voter and registration system must provide:  Connection Confidentiality  Connection Integrity  |
|---|---|--|--|
| 2 | Voter is not presented with correct ballot information due to incorrect candidate identification.   | Incorrect identification during candidate registration.  | Trusted candidate identification and registration are needed using:  - Security Procedures.  - Best Practices.  - Secure communications channels.  - Authentication and identification of candidates |
|   |   |  | The candidate registration must follow standard Security Operating Procedures (SOPs) which ensure due diligence has been done.   |
| 3 | Registration system impersonation   | Inadequate authentication of registration system   | Channels to and from the registration system must provide point to point authentication.   |
| 4 | Impersonation of a legitimate registered voter  | Incorrect authentication at the time of casting vote.  | Trusted voter authentication  (i.e. the right to cast a vote in this contest)  |
|   |   | Inadequate privacy of the exchange between the voter and the electoral system when vote is cast.         | Channel to provide:  - Connection Confidentiality  - Connection Integrity  |
|   |   |  | - Between voter and e-voting system  |

| 5 | Obtaining the right to vote illegally from a legitimate voter.  | Stealing the voter's voting card (e.g. the VToken data).                             | Some secret data only known to the voter's is required to be presented at the time of casting a vote.                                     |
|---|---|--|---|
|   | This may be by intimidation, theft or by any other means by which voting right has been obtained illegally.  For example, by  Stealing a voting card from a legitimate voter. | Any means of getting a legitimate voter to reveal his VToken data.                   | Before a vote is counted as a valid vote proof must be provided that the voter's secret data was present at the time of casting the vote. |
| 6 | Voting system impersonation   | Inadequate authentication of registration system                                     | Channel to provide:   |
|   |   | Inadequate authentication of voting casting point  (e.g. polling station/ballot box) | Point to point authentication Channel to provide: Point to point authentication   |
| 7 | Voter is not presented with correct ballot information  | Inadequate integrity of the ballot information                                       | Trusted path to voter on ballot options   |
|   |   |  | Integrity of the ballot information   |
|   |   | Given to the user  | Integrity of cast votes   |
|   |   | Held in the voting system  |   |
|   |   | The casting options available to the voter are not genuine                           | Trusted path between voter and vote recording   |
|   |   | Trojan horse, man in the middle attack   | Trusted path to voter on ballot options   |
| 8 | How do I know the voting system records votes   | Integrity of the voting system   | Non-repudiation of the vote   |
|   | properly  |  | Non-repudiation the vote was cast by a genuine voter Audit of voting system   |
|   |   |  | Connection confidentiality  |
|   |   | Insecure channel between   | Connection Integrity  |
|   |   | the voter and the vote casting point   | Connection Confidently  |
|   |   | Voter's intent is recorded accurately  | Trusted path between voter and vote recording   |
|   |   |  | Non-repudiation of the vote   |

|    |   |   | recorded   |
|----|---|---|--|
|    |   | Proof that a genuine vote has been accurately counted | Audit  |
| 9  | How can I be sure the voting system will not disclose whom I have voted for | Voter's identification is revealed                    | Voter's identification is anonymous                                  |
|    |   |   | Vote confidentiality   |
| 10 | How can it be sure that my vote has been recorded                           | Loss of vote  | Proof of vote submission   |
| 11 | How can I be sure there is no man-in-the- middle that                       | Vulnerable client environment;                        | Physical security  |
|    | can alter my ballot   | Trojan horses   | Procedural security  Unpredictable Coded voting                      |
|    |   | Virus   | information  |
|    |   | Interception of communication                         | Integrity of communications channel between client and server system |
| 12 | All votes counted must be have been cast by a legitimate voter              | Voter impersonation                                   | Voter authentication   |
|    |   | Audit facility fails to provide adequate proof        | Non-repudiation of the vote record                                   |
|    |   |   | Non-repudiation that legitimate voters have cast all votes.          |
|    |   | Breaking the vote counting mechanisms                 | Independent audit  |
| 13 | Only one vote is allowed per voter, per contest                             | Voter impersonation at registration                   | User registration security   |
|    |   | Multiple registration applications                    | Procedures   |
|    |   |   | Voter Identification   |
|    |   | Multiple allocation of voters credentials             | Voter authentication   |
| 14 | The vote cannot be altered from the voter's intention                       | Vulnerable client environment;                        | Trusted path from voter's intent to vote record                      |
|    |   | Trojan horses   | Vote integrity   |
|    |   | Virus   | Vote non-repudiation   |
| 15 | The vote may not be observed until the proper time                          | Votes may be observed before the end of the contest   | Voter confidentiality  |
| 16 | The voting system must be   |   | Non-repudiation of vote data.  |
|    | accountable and auditable   |   | Audit tools  |
| 17 | Identification and authentication information to and from the voter must be | Loss of privacy                                       | Channel to provide:  Connection Confidentiality                      |
|    | privacy protected   |   | ,  |

| 18 | The voter's actual identity may need to be anonymous | Voter's identification is revealed | Voter's identification is anonymous  |
|----|--|------------------------------------|--|
|    |  | Denial of service attack           |  |
| 19 | Denied access to electronic voting station           |                                    | This needs to be counted by engineering the system to provide survivability when under denial of service attack. |

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## **B.3 The Timestamp Schema**

Although used as part of EML, this schema has been put in a separate namespace as it is not an integral part of the language. A time-stamp binds a date and time to the sealed data. The time-stamp seal also protects the integrity of the data. The structure of the time-stamp is similar to the structure of an XML Signature.

- 1371 The timestamp structure may be used in one of two ways either:
- Using Internet RFC 3161 binary encoded time-stamp token with the time-stamp information repeated in XML,
- Using a pure XML encoded time-stamp.
- 1375 In the case of the RFC 3161 based time-stamp, the Timestamp structure is used as follows:
- within TimestampedInfo:
- TSTOrSignatureMethod identifies RFC 3161.
- Reference contains the URI reference of the voting data being time-stamped. The DigestValue sub element contains the digest of the voting data being time-stamped.
- TSTXMLInfoReference is not present in this case.
  - SignatureOrTSTValue holds the RFC 3161 time-stamp token applied to the digest of TimestampedInfo. The TimestampedInfo is transformed to a canonical form using the method identified in CanonicalizationMethod before the digest algorithm is applied.
- KeyInfo contains any relevant certificate or key information.
- Object contains the TSTXMLInfo element which is a copy of the information in SignatureOrTSTValue converted from RFC 3161 to XML encoding. The TSTXMLInfo element contains:
- the version of time-stamp token format. This would be set to version 1
- the time-stamping policy applied by the authority issuing the time-stamp,
- the time-stamp token serial number,
- the time that the token was issued, the contents of this element indicate the time of the timestamp.

- optionally an indication as to whether the time-stamps are always issued in the order that requests are received
- optionally a nonce<sup>2</sup> given in the request for the time-stamp token,
- optionally the identity of the time-stamping authority
- 1395 In the case of a pure XML encoded time-stamp, the Timestamp structure is used as follows:
- 1396 within TimestampedInfo,
- TSTOrSignatureMethod identifies the algorithm used to create the signature value.
- Reference contains the URI reference of the voting data being time-stamped. The DigestValue sub element contains the digest of the voting data being time-stamped.
- TSTXMLInfoReference must be present, and contains the URI reference of TSTXMLInfo as contained within the Object element. The DigestValue sub element contains the digest of the TSTXMLInfo.
- SignatureOrTSTValue contains the signature value calculated over the TimestampedInfo using the signature algorithm identified in TSTOrSignatureMethod having been transformed to a canonical form using the method identified in CanonicalizationMethod. This signature is created by the time-stamping authority.
- KeyInfo contains any relevant certificate or key information.
- Object contains the XML encoded time-stamp information in an TSTXMLInfo element. The contents of TSTXMLInfo is the simular as for the case described above. However, in this case the information is directly signed by the time-stamping authority. The TSTXMLInfo element contains:
- version of time-stamp token format: This would be set to version 2
- the time-stamping policy applied by the authority issuing the time-stamp,
- the time-stamp token serial number,
- the time that the token was issued, this is the time of the timestamp.
- optionally an indication as to whether the time-stamps are always issued in the order that requests
   were received
- optionally a nonce given in the request for the time-stamp token,
- optionally the identity of the time-stamping authority.

## 1419 B.4 W3C XML Digital Signature

- Some information on the digital signature is included here, but for full information refer to the
- 1421 Recommendation at http://www.w3.org/TR/xmldsig-core/
- 1422 An XML Signature consists of:

<sup>2</sup> A nonce is a parameter that varies over time and is used as a defence against a replay attack.

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- SignedInfo which includes a sequence of references to the data being signed with the digest (eg. SHA-1 hash) of the data being signed
- SignatureValue which contains the signature value calculated over the SignedInfo using the signature algorithm identified in SignatureMethod having been transformed to a canonical form using the method identified in CanonicalizationMethod
- KeyInfo contains any relevant certificate or key information.
- Object can contain any other information relevant to the signature

# C. Processing using Schematron or CAM

1431 This section gives a short introduction to how validation can be achieved using either Schematron 1432 schemas or the OASIS CAM template approach. For Schematron this is done either using an XSLT 1433 processor tool (such as Saxon), or by direct validation using the Schematron schemas and a dedicated 1434 Schematron processor. For CAM templates this is using a conforming implementation toolkit such as the 1435

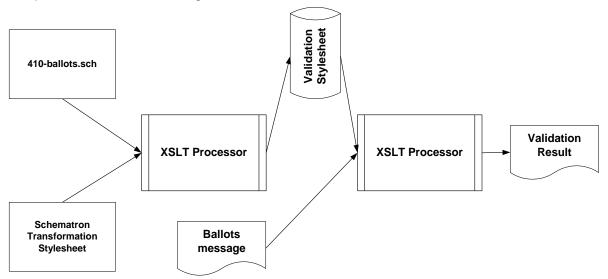
camprocessor project on SourceForge.net as open source.

#### **Validation using Schematron Schemas**

1437 A Schematron schema is an XML document that can be converted to XSLT using an XSLT stylesheet. There is a published stylesheet (skeleton1-5.xslt) that can be used to achieve this. This produces an 1438 1439 HTML output from the validation. A separate stylesheet can be produced that will create an output to the 1440 specification below. This stylesheet can import the skeleton and just over-ride those aspects where 1441 changes are required.

This stylesheet can be used once on each Schematron schema to produce the XSLT file that will be used for validating a specific message type. This stylesheet is then used to transform the incoming EML message into an error report based on the additional constraints.

1445 The process is shown in the diagram below.



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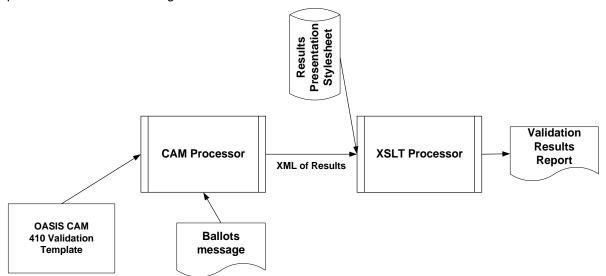
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## **Validation using OASIS CAM Templates**

An OASIS CAM (Content Assembly Mechanism) Template is an XML document that provides the ability to rapidly tailor the XSD schema structure definitions in the base EML standard to suit country localizations and rules. The CAM template can then be used to validate the particular implementation XML transactions. An open source toolkit is available that implements the OASIS CAM specification. A default template can be generated using this toolkit by ingesting the particular EML XSD schema, and then tailoring that to produce a country localization pick list and customizations of the content rules. The toolkit will also allow the generation of realistic example XML test case instances and localization documentation.

1455 1456 1457 Once test cases and templates are available then these can be validated using the CAM toolkit. The process is shown in the diagram below.



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| Revision           | Date       | Editor(s)             | Changes Made  |  |
|--------------------|------------|-----------------------|---|--|
| V0.1a              | 2002-02-07 | P Spencer             | Draft e-voting schemas for internal comment   |  |
| V0.2a              | 2002-02-13 | P Spencer             | Draft e-voting schemas for internal comment   |  |
| V0.3a 2002-03-22 I |            | P Spencer             | Draft e-voting schemas for public consultation comment  |  |
| V0.4               | 2002-04-18 | P Spencer             | Draft Committee Specification version 2   |  |
| V1.0               | 2002-04-29 | P Spencer             | Committee Specification for Technical Committee approval  |  |
| V1.0               | 2002-05-13 | P Spencer             | Committee Specification   |  |
| V2.0a              | 2002-06-13 | F Ahmed               | Revised draft accommodating committee's comments  |  |
| V2.0b              | 2002-07-15 | F Ahmed               | Draft Committee Specification for Technical Committee approval  |  |
| V2.0               | 2002-09-05 | F Ahmed               | Committee Specification   |  |
| V3.0a              | 2002-12-12 | F Ahmed               | Draft Committee Specification   |  |
| V3.0b              | 2003-02-06 | F Ahmed               | Draft Committee Specification for Technical Committee approval  |  |
| V3.0               | 2003-02-24 | F Ahmed               | Committee Specification   |  |
| V4.0a              | 2003-10-05 | J Borras              | Revised draft accommodating requirements of Council of Europe Member States and UK pilots   |  |
| V4.0b              | 2004-01-27 | J Borras              | Draft Committee Specification   |  |
| V4.0c              | 2004-03-09 | J Borras              | Revised draft by placing Schema Description section in document of its own due to excessive size of v4.0b.  Draft Committee Specification for Technical Committee approval. |  |
| V4.0d              | 2004-09-03 | J Borras              | Draft Committee Specification for Technical Committee approval.   |  |
| V4.0               | 2005-01-24 | J Borras              | Committee Specification   |  |
| V4.0               | 2006-02-01 | J Borras              | OASIS Standard  |  |
| V5.0               | 2007-03-14 | J Borras              | Committee Draft   |  |
| V5.0               | 2007-09-12 | J Borras              | Committee Specification   |  |
| V5.0               | 2007-12-01 | J Borras              | OASIS Standard  |  |
| V6.0               | 2009-08-18 | J Borras, D<br>Webber | Committee Draft 01  |  |
| V6.0               | 2009-08-18 | J Borras, D<br>Webber | Public Review Draft 01  |  |
| V6.0               | 2010-06-11 | J Borras, D<br>Webber | Committee Draft 02  |  |
| V6.0               | 2010-06-18 | J Borras, D<br>Webber | Public Review Draft 02  |  |