



Election Markup Language (EML) Specification Version 6.0

Committee Specification 01

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Related work:

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- [Election Markup Language \(EML\) v5.0](#)

See also:

- [EML Data Dictionary](#)
- [EML Schemas](#)
- [EML Core Components](#)

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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

covers the conventions used in the specification and the use of namespaces, as well as the guidance 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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Table of Contents

1.	Executive Summary	6
1.1	Overview of the Document.....	7
1.2	Terminology	7
1.3	Normative References	7
1.4	Non-Normative References	7
2.	Introduction.....	8
2.1.	Business Drivers.....	8
2.2.	Technical Drivers	8
2.3.	The E&VS Committee.....	9
2.4.	Challenge and Scope.....	10
2.5.	Documentation Set	11
2.6.	Voting Terminology	12
3.	High-Level Election Process.....	14
3.1.	Outline	17
3.2.	Process Descriptions	17
3.3.	Data Requirements	25
4.	Schema Outline.....	28
4.1.	Structure	28
4.2.	Viewing Schemas	28
4.3.	IDs	28
4.4.	Displaying Messages.....	29
4.5.	EML Message Validation	32
4.6.	Namespaces.....	32
4.7.	Extensibility.....	32
4.8.	Additional Constraints.....	32
4.9.	Metadata.....	32
4.10.	Splitting of Messages.....	33
4.11.	Error Messages	33
4.12.	All Schemas.....	33
5.	Schema Descriptions.....	36
5.1	Overview.....	36
5.2	EML Core Components	38
5.3	Message Schemas	38
6.	Conformance.....	49
A.	Acknowledgements	50
B.	Other Considerations.....	51
B.1	Security	51
B.2	Internet Voting Security Concerns.....	58
B.3	The Timestamp Schema	62
B.4	W3C XML Digital Signature.....	63
C.	Processing using Schematron or CAM.....	65

D. Revision History 67

1. Executive Summary

OASIS, the XML interoperability consortium, formed the Election and Voter Services Technical Committee in the spring of 2001 to develop standards for election and voter services information using XML. The committee's mission statement is, in part, to:

“Develop a standard for the structured interchange among hardware, software, and service providers who engage in any aspect of providing election or voter services to public or private organizations...”

The original objective in 2001 was to introduce a uniform and reliable way to allow systems involved in 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

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 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.

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.)
- 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.

This document and its accompanying set of schemas do not claim to satisfy the final requirements of any 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 any requirement gaps, mistakes, inconsistencies or missing data and to propose corrections or enhancements to the OASIS Election and Voter Services Technical Committee.

41 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
44 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.

46 **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.

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
52 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
55 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
59 schema; the W3C Digital Signature technology; and Acknowledgements and a revision history.

60

61 1.2 Terminology

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

65 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/ciq/v3.0/specs/ciq-specs-v3.pdf>

72 [UK’s APD] Address and Personal Details Fragment v1.1 Technology Policy Team, e-Government
73 Unit, Cabinet Office UK, 1 March 2002
74 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
76 Consortium, 4 February 2004 <http://www.w3.org/TR/REC-xml>

77 [XML-DSig] XML-Signature Syntax and Processing Donald Eastlake et al, Worldwide Web
78 Consortium, 10 June 2008 <http://www.w3.org/TR/xmlsig-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>

81

82

2. Introduction

83

2.1. Business Drivers

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

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

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

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

107

2.2. Technical Drivers

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

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

118

119

120 **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
123 on delivering and maintaining a **reliable, accurate and trusted** XML specification (Election Markup
124 Language (EML)) for the structured interchange of data and referencing of data among hardware,
125 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
127 verifiable way to allow e-voting systems to interact as global election processes evolve and are adopted.

128 The Committee's mission statement is:

129 *"To develop a standard for the structured interchange of data among hardware, software, and service*
130 *providers who engage in any aspect of providing election or voter services, be they partly paper-based or*
131 *fully e-enabled, to public or private organizations. The services performed for such elections and*
132 *referenda include but are not limited to:*

- 133 • *candidate nomination,*
- 134 • *referendum options nomination,*
- 135 • *voter registration,*
- 136 • *polling places, districting and boundaries*
- 137 • *various communications between voters and elections officials,*
- 138 • *ballot information*
- 139 • *voter authentication*
- 140 • *vote casting and vote confirmation*
- 141 • *election counts, statistics and results."*

142

143 The primary function of an electronic voting system is to capture voter preferences reliably, securely and
144 report them accurately with legally requirements for privacy met correctly. Capture is a function that
145 occurs between 'a voter' (individual person) and 'an e-voting system' (machine). It is critical that any
146 election system be able to prove that a voter's choice is captured correctly and anonymously, and that the
147 vote is not subject to tampering, manipulation or other frauds.

148 These universal democratic principles¹ can be summarized as a list of fundamental requirements, or 'six
149 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
152 cast a vote.
- 153 3 Do not permit tampering with the voting systems operations, nor allow voters to sell their votes.

¹ 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].
157 In addition to these business and technical requirements, the committee was faced with the additional
158 challenges of specifying a requirement that was:
- 159 • Multinational – our focus is to have these standards adopted globally
 - 160 • Effective across the different voting regimes – for example, proportional representation or ‘first past
161 the post’, preferential voting, additional member system
 - 162 • Multilingual – our standards will need to be flexible enough to accommodate the various languages
163 and dialects and vocabularies
 - 164 • Adaptable – our aim is to provide a specification that is resilient enough to support elections in both
165 the private and public sectors
 - 166 • Secure – the standards must provide security that protects election data and detects any attempt to
167 corrupt it.

168 The Committee has followed these guidelines and operated under the general premise that any data
169 exchange standards must be evaluated with constant reference to the public trust.
170

171 **2.4. Challenge and Scope**

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

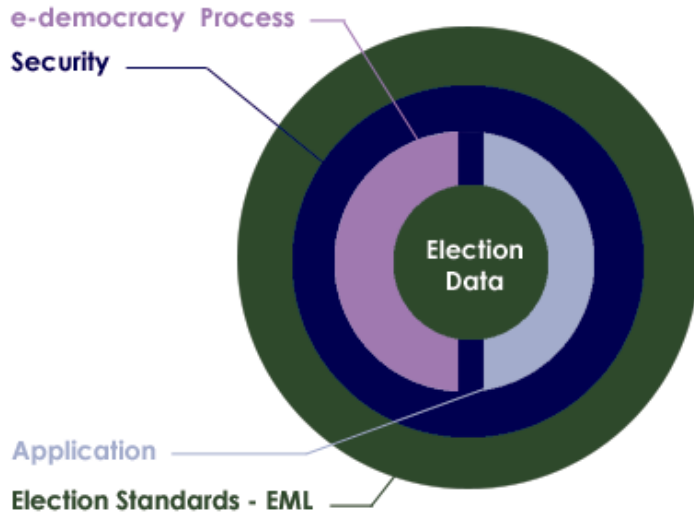
178 These processes are illustrative, covering the vast majority of election types and forming a basis for
179 defining the Election Markup Language itself. EML has been designed such that elections that do not
180 follow this process model should still be able to use EML as a basis for the exchange of election-related
181 messages.

182 EML is focused on defining open, secure, standardized and interoperable interfaces between
183 components of election systems and thereby providing transparent and secure interfaces between
184 various parts of an election system. The scope of election security, integrity and audit included in these
185 interface descriptions and the related discussions are intended to cover security issues pertinent only to
186 the standardized interfaces and not to the internal or external security requirements of the various
187 components of election systems.

188 The security requirement for the election system design, implementation or evaluation must be placed
189 within the context of the vulnerabilities and threats analysis of a particular election scenario. As such the
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
193 mechanisms described in this document are all optional, enabling compliance with EML without regard for
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
200 data between the various end-to-end election stages and processes in a standardized way.

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



206
207 *Figure 1A: e-Voting Components Relationship Overview*

208

209 **2.5. Documentation Set**

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

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

219 The document set comprises:

- 220 • **Specification:** This document. A general and global study of the electoral process. This introduces
221 the transition from a complete manual election management process to a digitally enabled end-to-end
222 election system by defining the data structures of content to be exchanged and or produced and
223 where these data structures are needed, and describe how those exchanges and artifacts are
224 encoded as XML schemas.
- 225 • **Data Requirements:** A data dictionary defining the data used in the processes and required to be
226 handled by the XML schemas. The data dictionary is provided in both XML and spreadsheet formats.
227 In addition there are data models available in the 'EML v6.0 Data Models' file.
- 228 • **EML Schemas:** This consists of a library of the XML schemas used in EML. The XML schemas
229 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.

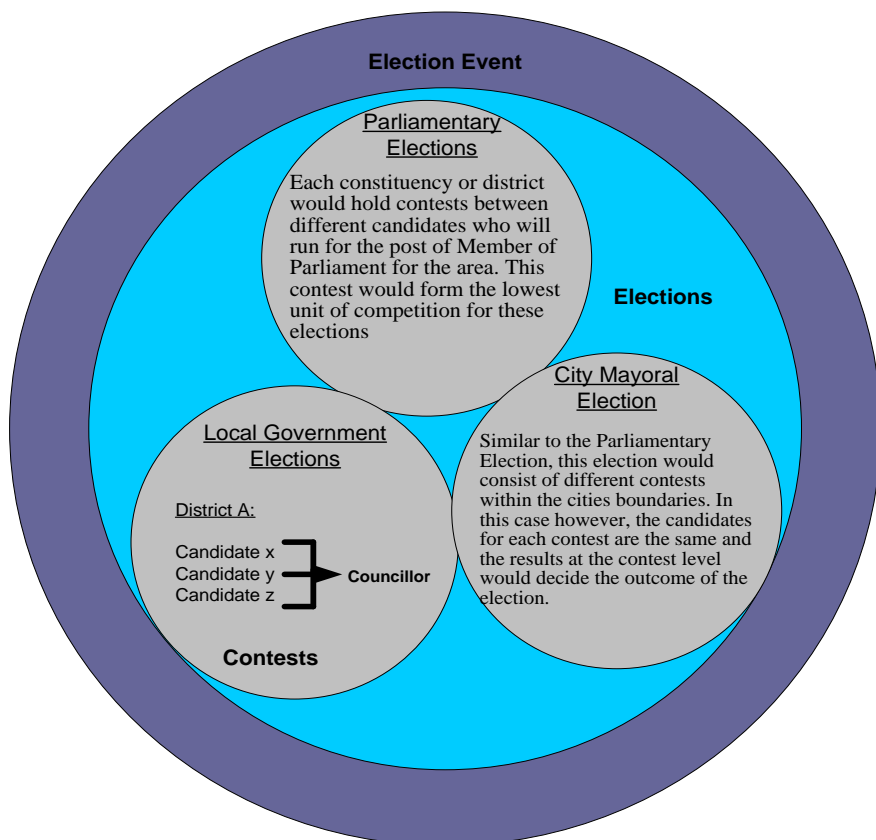
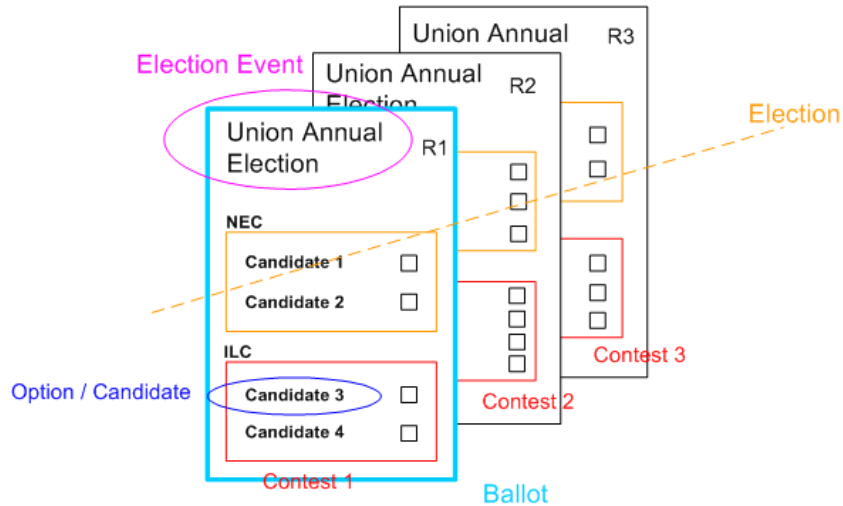


Figure 12B: The Election Hierarchy

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

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



260
 261 *Figure 13C: Union Annual Election Event*

262

3. High-Level Election Process

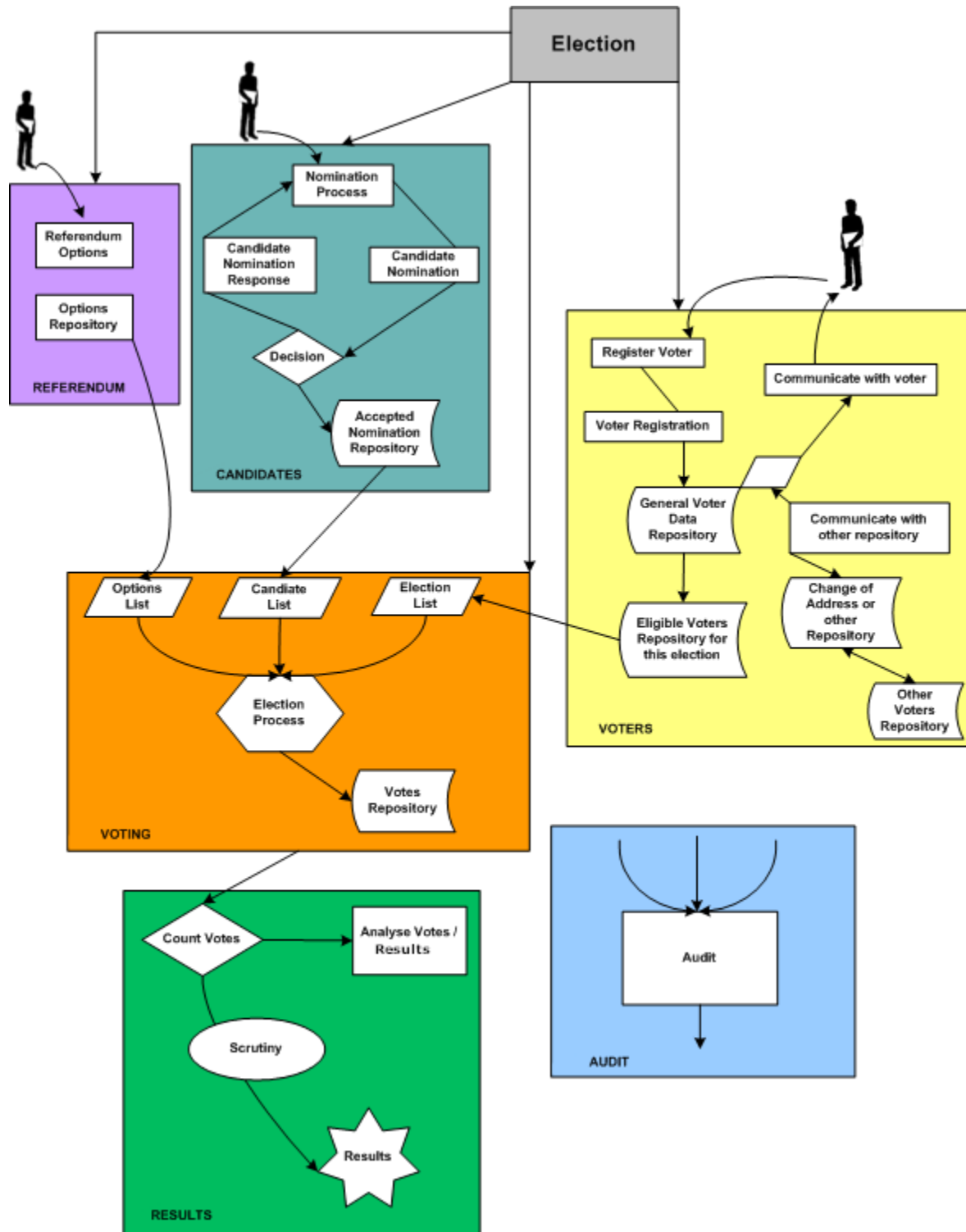
263 Section 3 describes two complementary high level process models of an election exercise, based on the
264 human and technical views of the processes involved. It is intended to identify all the generic steps
265 involved in the process and highlight all the areas where data is to be exchanged.

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

269

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271
272

Figure 2A: High Level Model – Human View

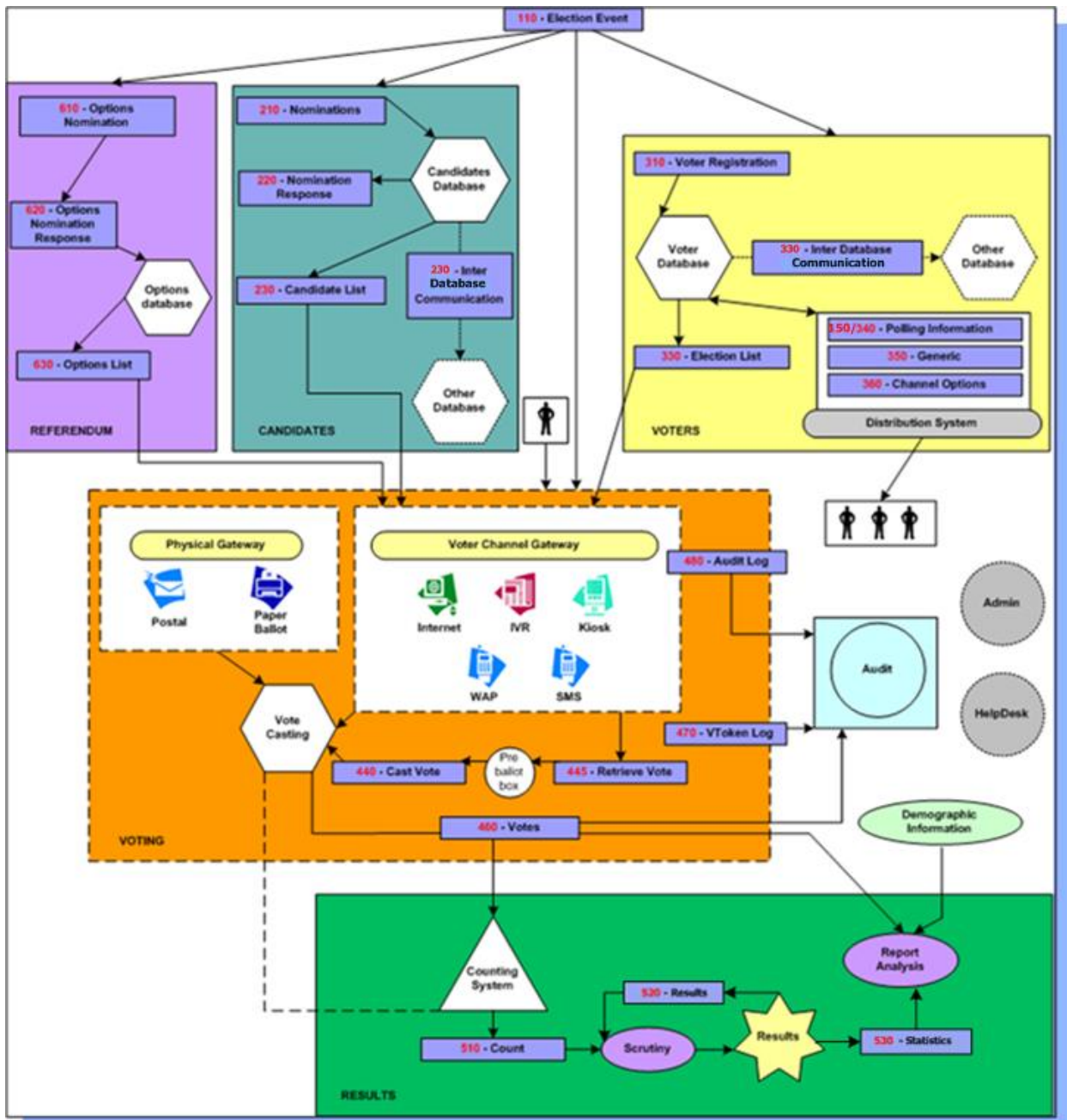


273
274

275 Figure 2B: High Level Model – Technical View

276

277



278

279

280

281

282 **3.1. Outline**

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

285 For clarity, the whole process can be divided into 3 major areas, pre election, election, post election; each
286 area involves one or more election processes. This document allocates a range of numbers for each
287 process. One or more XML schemas are specified to support each process, this ensures consistency with
288 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

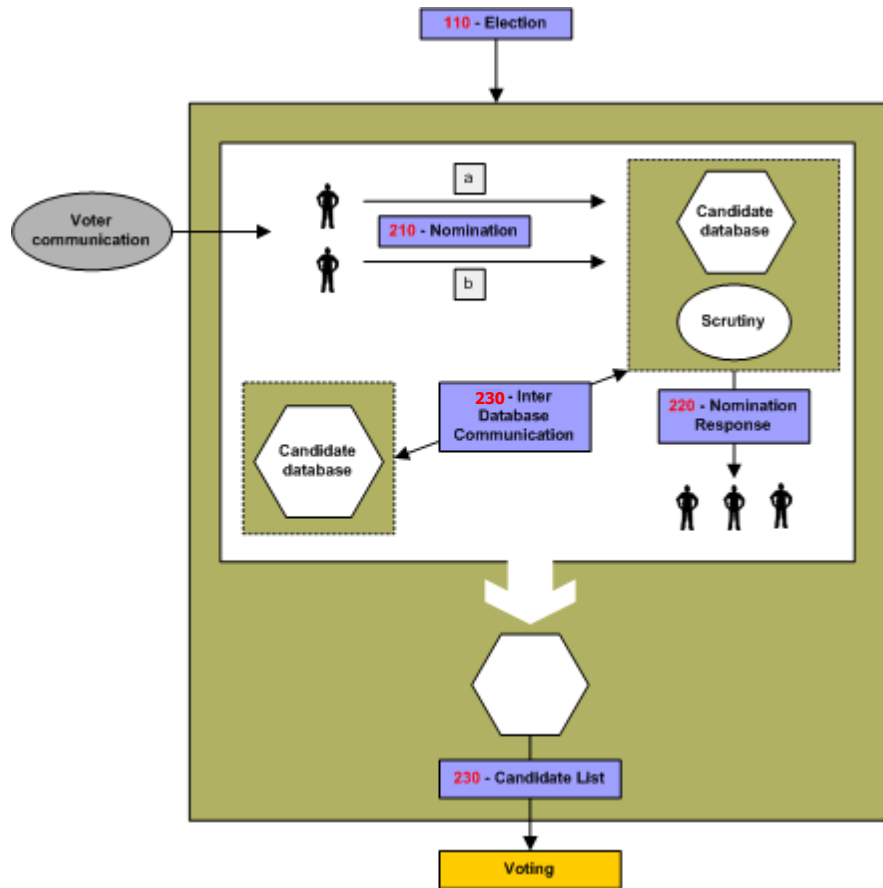
300 Some functions belong to the whole process and not to a specific part:

- 301 • Administration Interface
- 302 • Help Desk

303 **3.2. Process Descriptions**

304 **3.2.1. The Candidate Nomination Process**

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



307
308 *Figure 2C: The Candidate Nomination Process*

309
310 Irrespective of local regulations covering the nomination process, or the form in which a candidate's
311 nomination is to be presented, (e.g. written or verbal), the committee anticipates that the process will
312 conform to the following format:

- 313 • Voter Communications [350-Generic] declaring the opening of nominations will be used to reach the
314 population eligible to nominate candidates for a position x in an election y.
- 315 • Interested parties will respond in the proper way satisfying the rules of nomination for this election
316 with the objective of becoming running candidates. The response message conforms to schema 210.
- 317 • A nomination for an individual candidate can be achieved in one of two ways:
- 318 • A Nominee will reply by attaching to his nomination a list of x number of endorsers with their
319 signature.
- 320 • Each endorser will send a message specifying Mr. X as his or her nominee for the position in
321 question. Mr X will signal his agreement to stand.

322 Note that nomination and the candidate's agreement to stand might be combined in a single message or
323 sent as two messages, each conforming to schema 210.

324 The election officer(s) of this specific election will scrutinize those replies by making sure the
325 requirements are fully met. Requirements for nomination vary from one election type to another, for
326 example some elections require the nominee to:

- 327 • Pay fees,

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

333 Schema 210 provides mechanisms to identify and convey scrutiny data but since the laws of nomination
 334 vary extensively between election scenarios, no specific scrutiny data is enumerated.

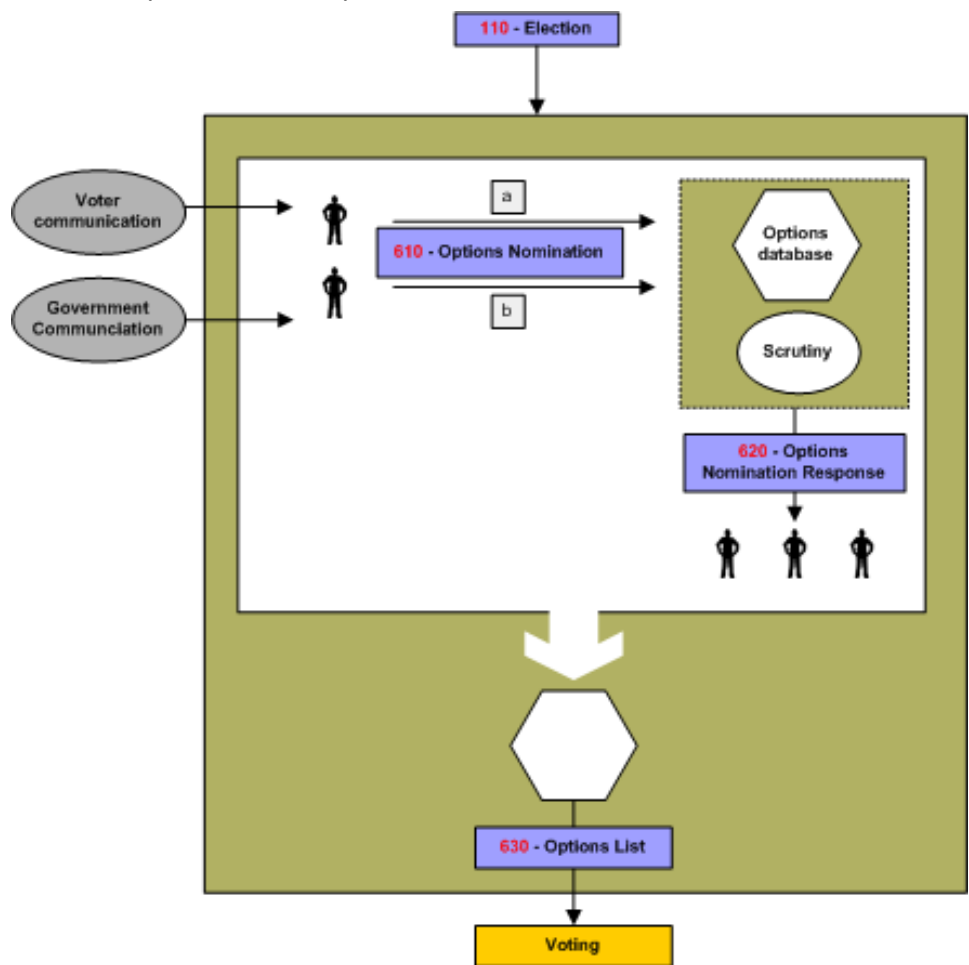
335 Schema 330 allows election officials to enquire of other jurisdictions whether a particular candidate is
 336 standing in more than one contest.

337 Nominees will be notified of the result of the scrutiny using a message conforming to schema 220.

338 The outcome of this process is a list of accepted candidates that will be communicated using a message
 339 conforming to schema 230. It will be used to construct the list of candidates for each contest.

340 3.2.2. The Options Nomination Process

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



344
 345 *Figure 2D: Referendum Options Nomination Process*

346

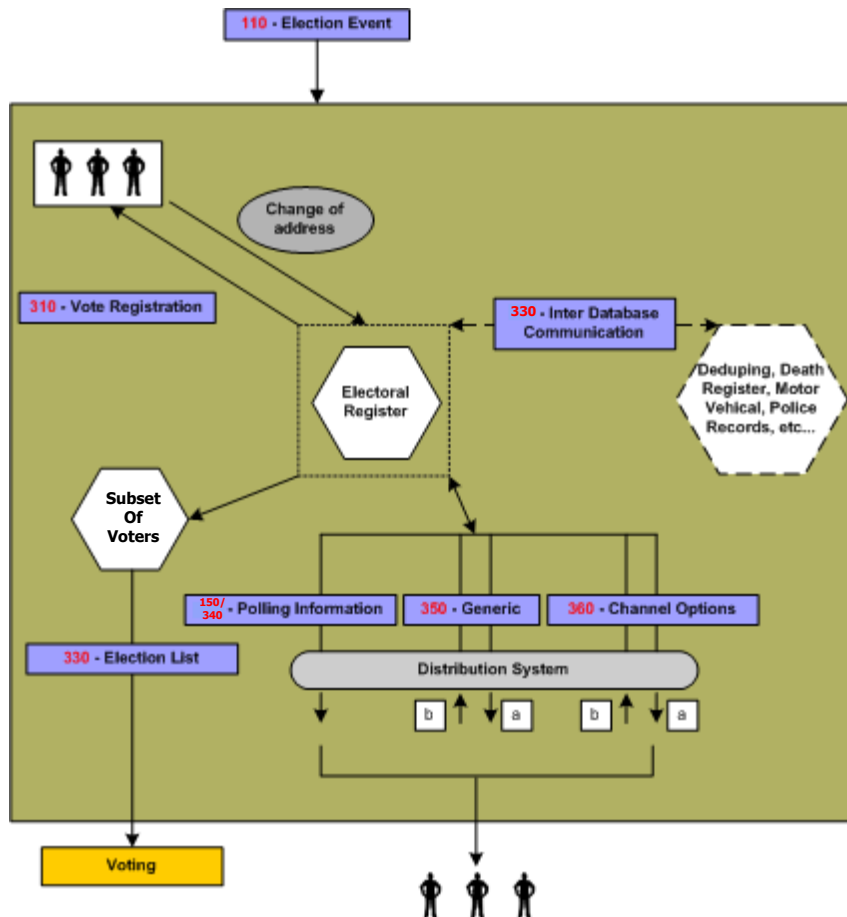
347 The nomination can be received in a number of ways including direct from government institutions or from
348 citizens or businesses, and schema 610 handles the receipt of nominations.

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

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

353 3.2.3. The Voter Registration

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



356

357 *Figure 2E: Voter Registration*

358

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

363 This schema of data exchange is recommended irrelevant of the method a voter uses to supply his
364 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.
371 Schemas contain some subset of the eligible voters, perhaps grouped by polling district or voting channel.

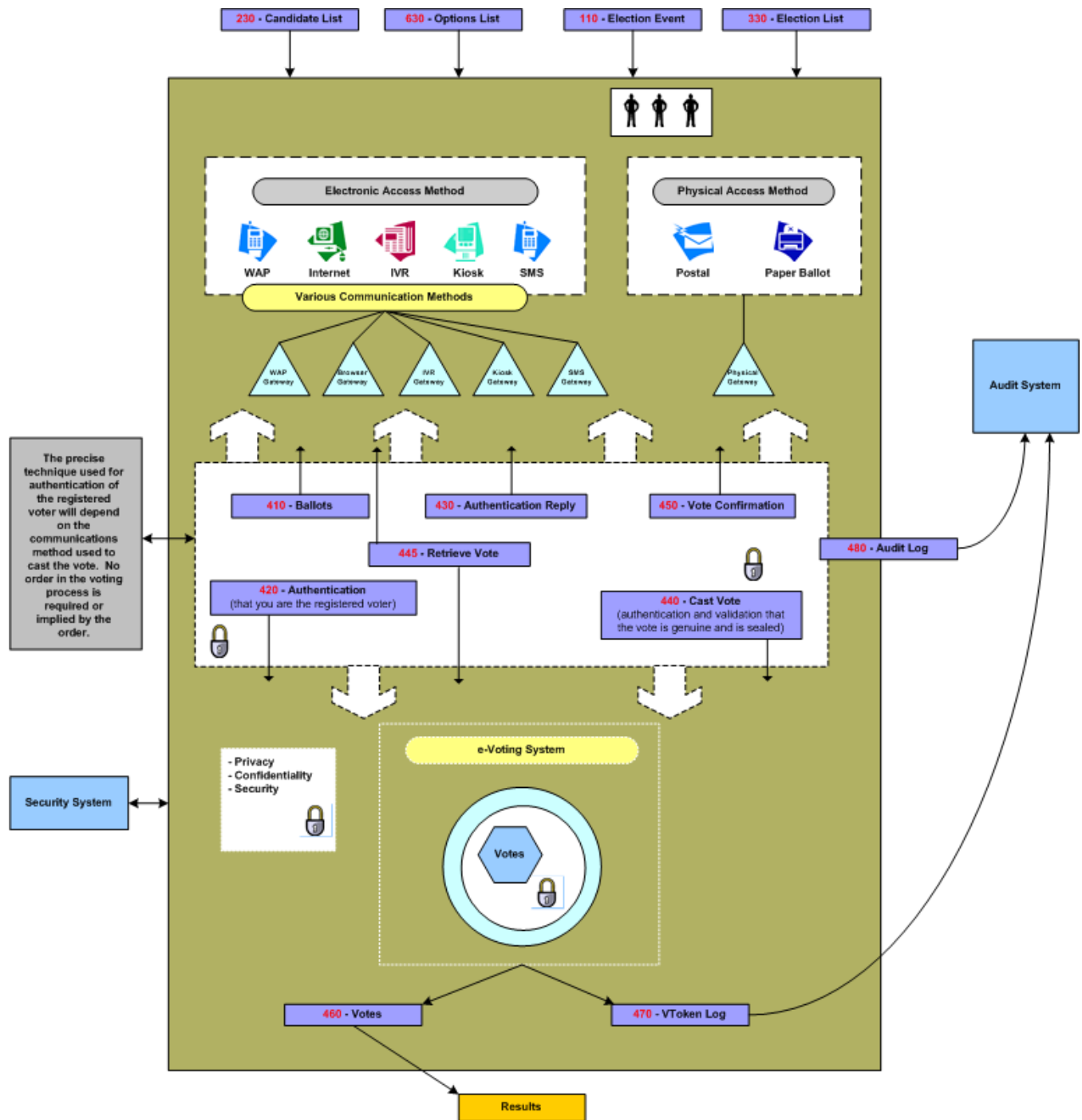
372 It is here that we introduce the concept of voter communications. Under this category we divided them
373 into three possible types of communications:

- 374 • Channel options
- 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.

379 **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.



381
 382 *Figure 2F: The Voting Process*
 383

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

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

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

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

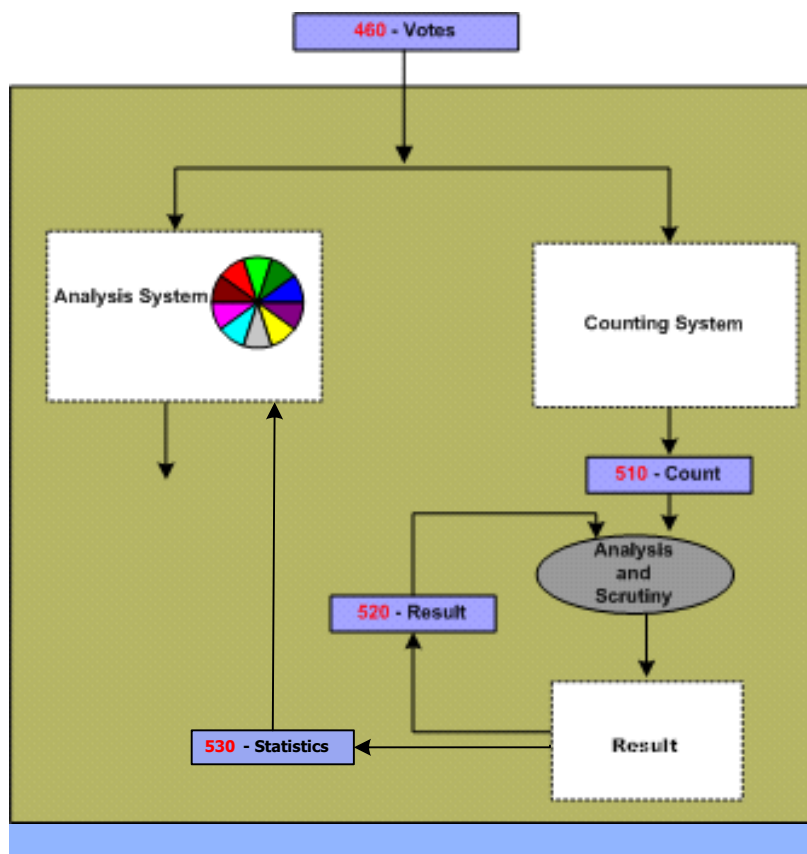
395 Where a voter's right to vote in any particular contest needs to be determined, this is defined by the
 396 parameters of his VToken. See Section 4 for more information on security and the VToken.

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

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

3.2.5. The Vote Reporting Process

405
 406 Two of the post election items are the Final or Interim Result and the Audit Report. Audit is discussed in
 407 3.4.6.



408
 409 *Figure 2G: The Vote Reporting Process*

411 The voting system should communicate a bulk of data representing the votes to the counting system or
 412 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.

414 Recount can be very simply accommodated by a re-run of the schema 460, on the same or another
 415 counting system.

416 Some voting methods, such as the additional member system (AMS), combine the result of one election
 417 with the votes of another to create a result. For an election run under the AMS, the results of the 'first past
 418 the post' (FPP) election can be communicated using a message conforming to schema 520. This schema
 419 can only be used for communicating the results of elections using simple voting methods such as FPP,
 420 and is not intended as a general purpose results schema.

421 The votes schema 460 also feeds into a variety of analysis systems, which can be used to provide for
 422 demographic, statistical or other types of election reports. The output of these analysis systems is outside
 423 the scope of this document.

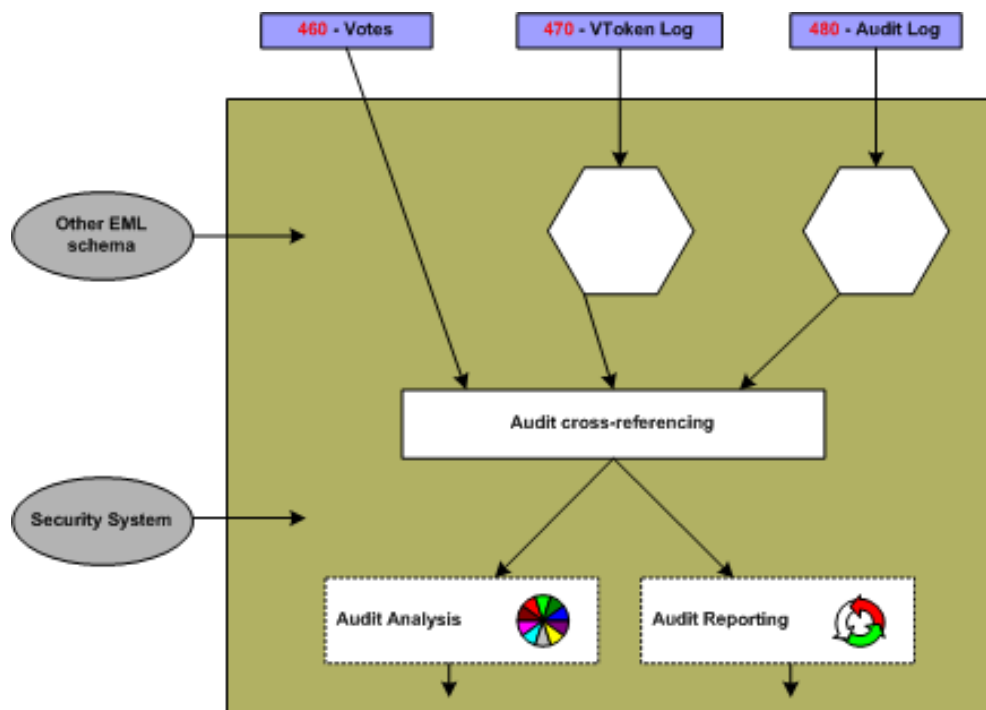
424 Schemas 510 and 520 allow for Simulation and Extrapolation of final or interim Counts and Results.
 425 Simulation being the facility to forecast the result of a contest based on the result of another contest.
 426 Extrapolation is the facility to forecast the final result of a contest based on the count so far.

427 Schema 530 allows for a variety of statistics to be extracted from the results and passed to analysis
 428 systems and other media outlets.

429 .

3.2.6. The Auditing System

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



434
 435 *Figure 2H: Auditing System*

436

437 A requirement is for the election officer to be able to account for all the ballots. A count of ballots issued
438 should match the total ballots cast, spoiled and unused.

439 Schemas 460, 470, 480 from the voting process provide input data to the audit process. Depending on
440 the audit requirements additional data from other processes may be required. In particular, the security
441 process may provide additional data about all the issued VTokens and Qualified VTokens (see Figure 3A:
442 Voting system security).

443 The security process ensures that the right to cast a vote is dictated by the presence of a VToken, thus in
444 order to provide accountability for all ballots as per the requirement above, reliable data from the security
445 system is required on the total number of:

- 446 • Eligible voters
- 447 • Issued VTokens or Qualified VTokens.

448 The audit process can collate the total number of VTokens and Qualified VTokens provided by the
449 security system with the total number reported by the voting system using schema 460 and 470.

450 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
454 confirms that the total number of votes presented by the output of the e-voting system in 460 is consistent
455 with the total number of submitted votes with seals.

456 The above correlation between trusted data provided by the security process and data provided by the
457 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
459 as recorded by the e-voting system.

460 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
462 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
464 a result is contested. The number of votes from the voting system using schema 460 can be verified by
465 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
467 verify an individual result.

468 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 is 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
472 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.

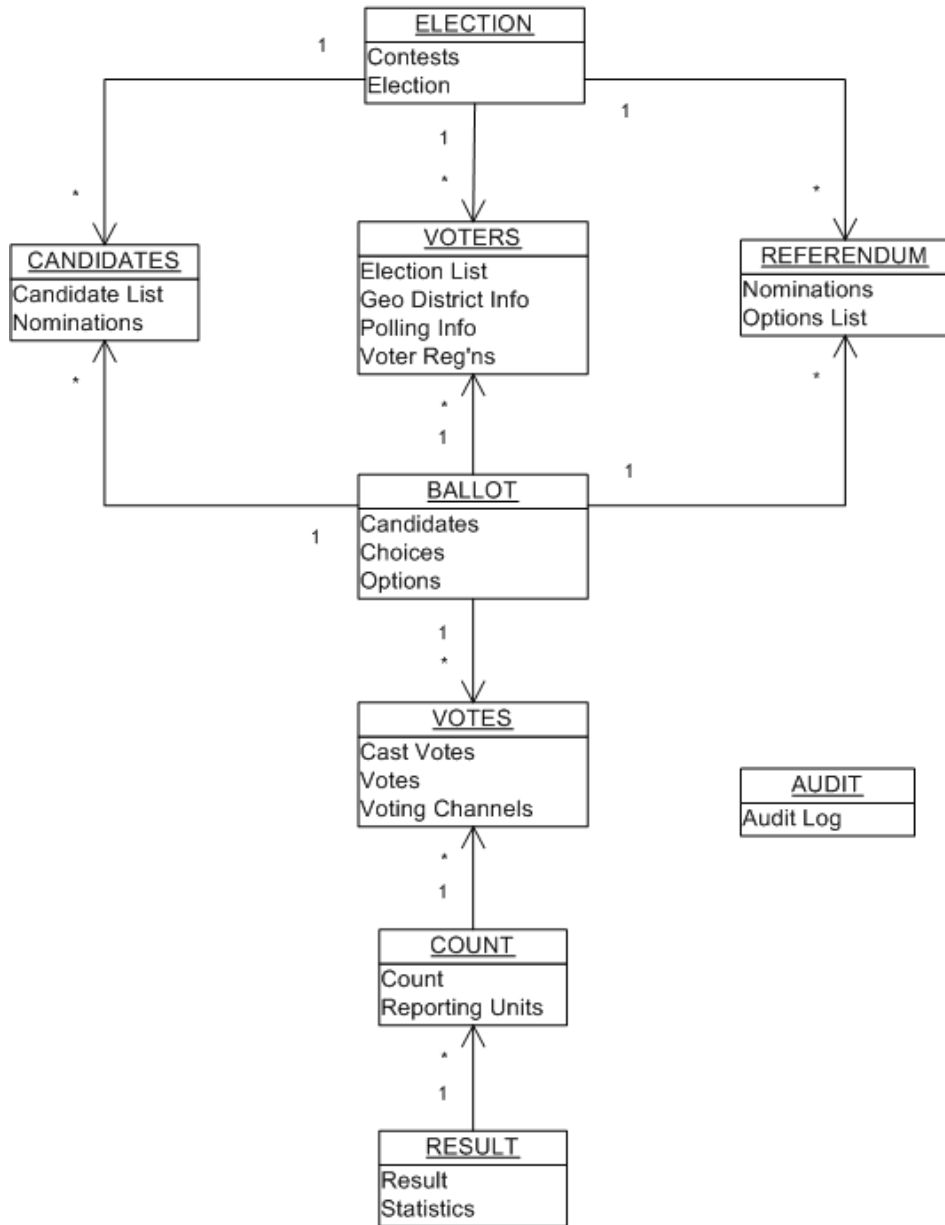
474 The above defines some of the election data that can be verified by the audit system. However, ideally
475 everything done by the various components of an election system should be independently verifiable. In
476 the scope of EML this means that the audit system may need to be able to process all 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.

479 **3.3. Data Requirements**

480 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
482 v6.0 Data Dictionary'. Fig 2j below shows the mapping between the data entities and the EML schemas.

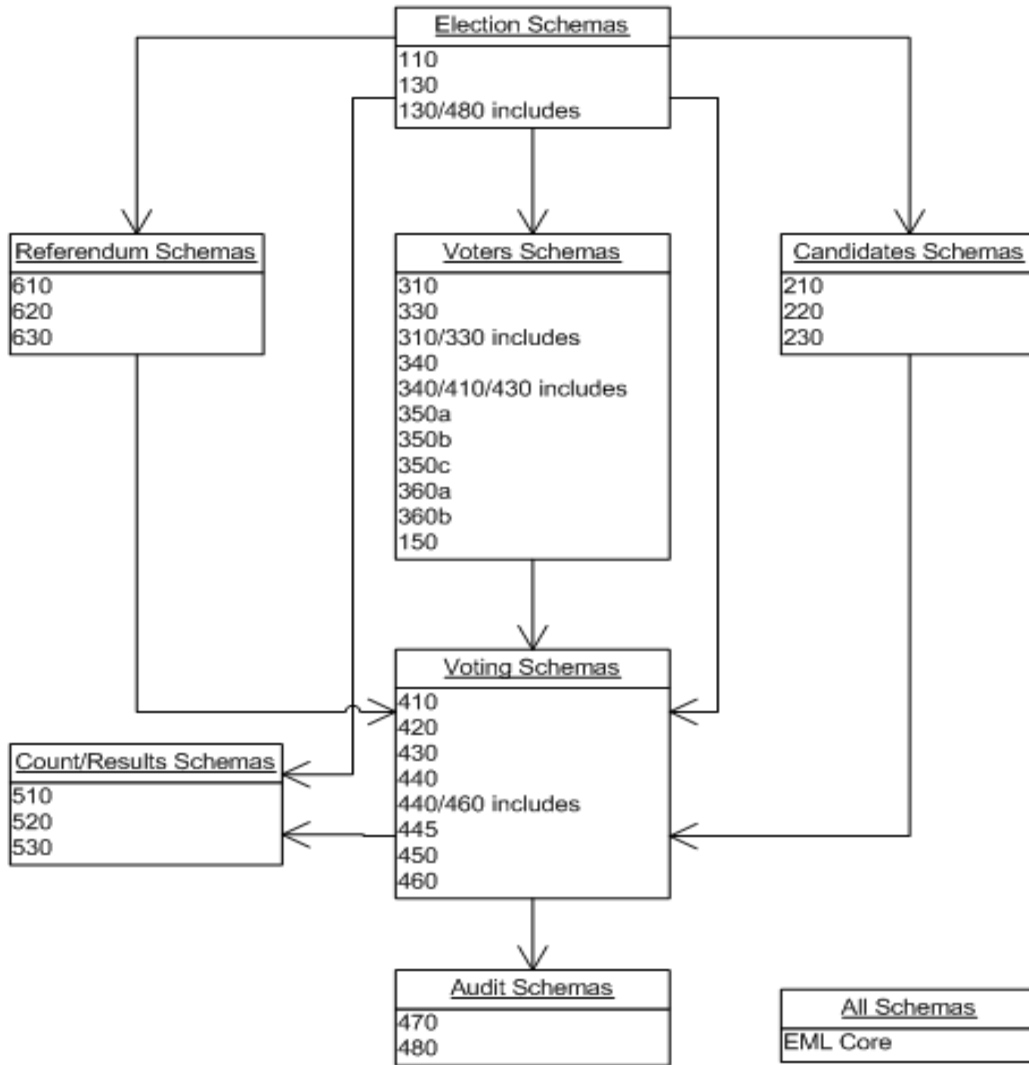
483

EML v6.0 Top Level Data Model



484
485 *Figure 2i: High-level Data Model*
486

EML v6.0 Entity/Schema Correlation



487

488

489 *Fig 2j Entity/Schema Mapping*

490 **4. Schema Outline**

491 **4.1. Structure**

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

497 In some cases, two or more message schemas have large parts in common. For example, a voter
498 authentication response message can contain a ballot that is almost identical to that used in the ballot
499 message. When this occurs, the relevant declarations are included in a file whose file name includes the
500 word 'include' and the number of the schemas in which it is used.

501 There is a third category of schema document within EML - the EML externals. This document contains
502 definitions that are expected to be changed on a national basis. Currently this comprises the name and
503 address elements, which are based on the OASIS Extensible Name and Address Language [1], but may
504 be replaced by national standards such as those contained in the UK Government Address & Personal
505 Details schemas [2]. Such changes can be made by replacing just this single file.

506 As well as these, several external schemas are used. The W3C has defined a standard XML signature
507 [5]. OASIS has defined schemas for the extensible Name and Address Language (xNAL) [1]. As part of
508 the definition of EML, the committee has defined a schema for the Timestamp used within EML. All these
509 schemas use their appropriate namespaces, and are accessed using xs:import directives.

510 Each message (or message group) type is specified within a separate schema document. All messages
511 use the EML element from the election core as their document element. Elements declared in the
512 individual schema documents are used as descendents of the EML element.

513 As an international specification, EML is generic in nature, and so needs to be tailored for specific
514 scenarios. Some aspects of the language are indicated in EML as required for all scenarios and so can
515 be used unchanged. Some aspects (such as the ability to identify a voter easily from their vote) are
516 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.

519 **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.

525 Each schema element has an Id attribute that relates to the message numbering scheme. Each message
526 also carries this number.

527 Some items will have identifiers related to the voting process. For example, a voter might be associated
528 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.

533 4.4. Displaying Messages

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

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

```
539 <?xml version="1.0" encoding="UTF-8"?>  
540 <EML  
541   Id="410"  
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     ...
```

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

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

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

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

572

Voting Paper

**National Executive Committee & International Liason Committee
Elections 2001-2003**

PLEASE READ THE VOTING INSTRUCTIONS BELOW BEFORE VOTING

The count for this election will be conducted by means of the Single Transferable Vote.

To cast your vote you should enter the number "1" against your first preference and the number "2" against your next preference.

Please do not use an "X". You may vote in both elections.

National Executive Committee
one to be elected

Option Number	Name	Order of Preference
101	J Chahal	1
102	S Ruston	1

International Liason Committee
one to be elected

Option Number	Name	Order of Preference
121	N Goodman	1
122	J Marcos	1

Name: J Chahal

I have worked within various organisations within our trade for fifteen years, gradually working my way up from the bottom. I have worked all over the country for these roles and have gained a good knowledge of what is involved with this committee.

Currently I provide a supporting role to the people on the National Executive Committee, this means that I have a working knowledge of what must be done and not just a theoretical understanding.

In my spare time I like to watch motor racing and enjoy keeping fit in general. I have always been extrovert and am not afraid to expressing opinions, both those of my own and of others. Also I like to make time to relax with my family and can often be found playing football with my son.

If you opt to cast your vote by post, please return your voting paper in the pre paid envelope provided to reach the Independent Scrutineer, election.com, PO Box 648, Wembley, HA0 1FA.

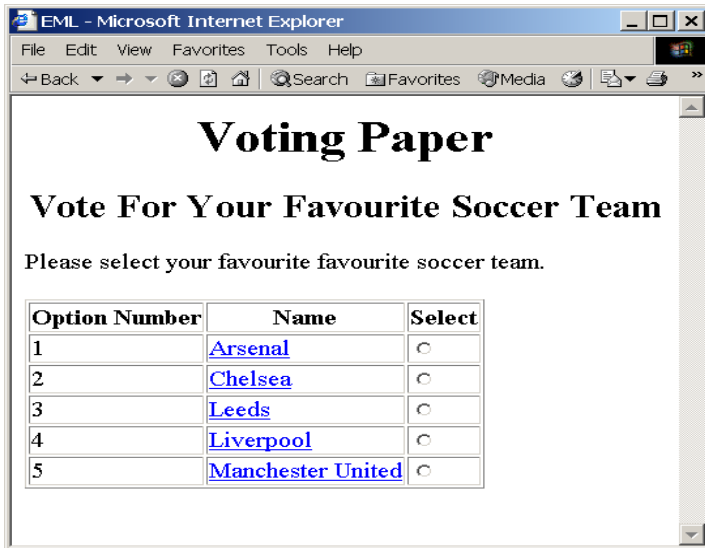
Your paper should arrive not later than midday on **FRIDAY 23RD MARCH 2001.**

If you vote using more than one method (internet, telephone or postal), your vote will be declared invalid.

573

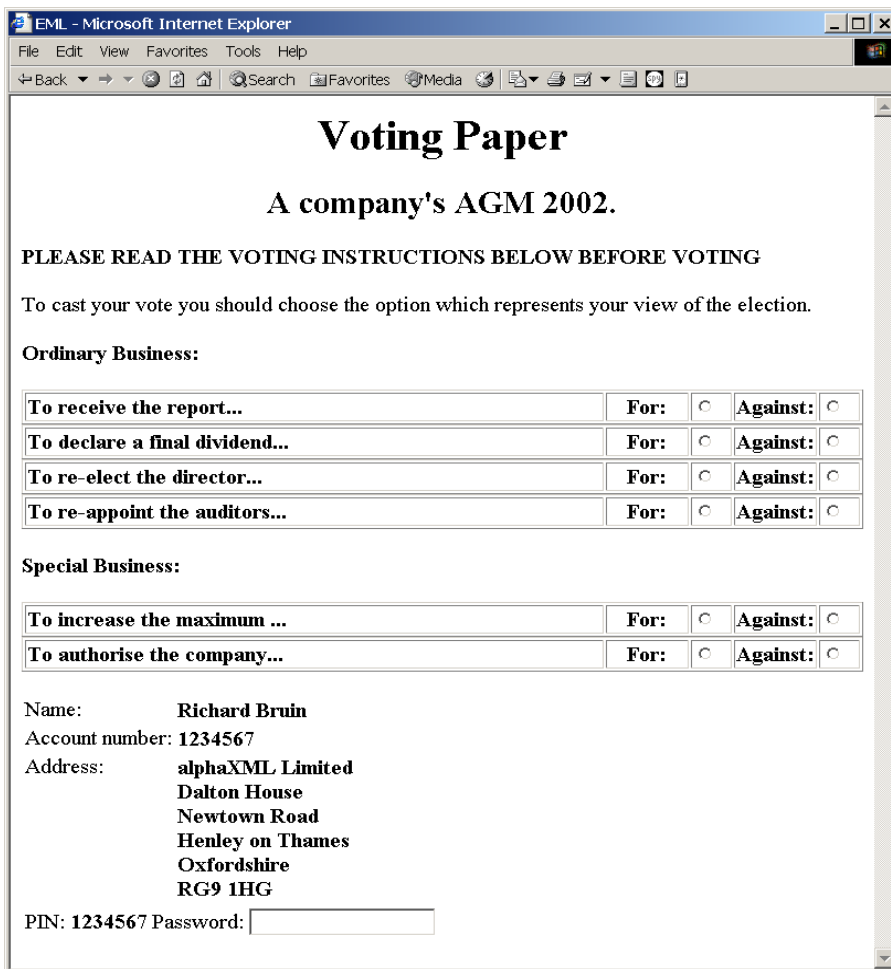
574 *Figure 3A: Screen shot of the ballot for scenario 1*

575



576
577
578

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



579
580

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

581

582 **4.5. EML Message Validation**

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

589 However, an implementation may choose to:

- 590 • modify the EML schemas to incorporate those application-specific constraints that can be
591 represented in W3C XML Schema;
- 592 • not validate the rules that are encoded as templates schemas (Schematron or CAM);
- 593 • not perform any validation; or
- 594 • develop some alternative backend validation.

595 **4.6. Namespaces**

596 The message schemas and the core schema are associated with the namespace
597 `urn:oasis:names:tc:evs:schema:eML`. This is defined using the prefix `eML`. The XML Schema
598 namespace `http://www.w3c.org/2001/XMLSchema` is identified by the prefix `xs` and the XML
599 Schema Instance namespace `http://www.w3c.org/2001/XMLSchema-instance` by the prefix `xsi`.

600 Use is also made of namespaces for the Extensible Name and Address Language (xNAL). The
601 Extensible Name Language namespace `urn:oasis:tc:ciq:xdschema:xNL:3.0` is identified by the
602 prefix `xNL`, and the Extensible Language namespace
603 `urn:oasis:names:tc:ciq:xdschema:xAL:3.0` by the prefix `xAL`.

604 **4.7. Extensibility**

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

608 **4.8. Additional Constraints**

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

615 **4.9. Metadata**

616 Some messages need information relating to the issuing of them, such as the issue date, who issued
617 them etc. This is most likely to be a requirement for the 330 message but is equally applicable to 130,
618 230, 350a and several others. For that reason, it is useful to make this optional information available in
619 the header. The information usually consists of: managing authority, date of issue, start of list period
620 (used for changes to the list to indicate the start of the period for which changes are being shown), end of
621 list period (i.e. the date of the snapshot of the list).

622 **4.10. Splitting of Messages**

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

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

634

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

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

638 **4.11. Error Messages**

639 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

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

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

647 **4.12. All Schemas**

648 **4.12.1. XML well-formedness or Schema validation error**

Error code	Error Description
------------	-------------------

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

649

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

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

Error Code	Error Description
3000-001	If there are processing units in the <code>AuditInformation</code> , one must have the role of sender
3000-002	If there are processing units in the <code>AuditInformation</code> , 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 <code>Id</code> attribute of the EML element is incorrect
3000-005	The message type must match the <code>Id</code> attribute of the EML element
3000-006	All messages that are split must include the correct sequenced element name.

653

	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	✓	
630	✓	

654

655

5. Schema Descriptions

656

5.1 Overview

657

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

658

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
response

Confirms whether the options nomination has been accepted.

EML 630 – options list

Use to transfer lists of proposals for a referendum

EML Core

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

659

660

661 **5.2 EML Core Components**

662 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.

666 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
668 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).

673 Related to classification of content type is the difference between Schema elements and types and
674 specifically Schema `xsd:complexType` usage and this is discussed next.

675

676 **5.2.1 Complex Data Types**

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

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

686 In use, it is expected that, for example:

- 687 • A voting token will always have an element name `VToken` and so will use the element name.
- 688 • A logo or a map have similar definitions, so both use the `PictureDataStructure`. There is no
689 `PictureData` element.
- 690 • Within voter identification, some elements will usually need to be made mandatory and so a schema
691 will specify a new element based on the `VoterIdentificationStructure` data type.

692

693 **5.3 Message Schemas**

694 This section describes the EML messages and how the message specifications change for this
695 application. It uses the element and attribute names from the schemas.

696 **Election Event (110)**

697 This schema is used for messages providing information about an election or set of elections. It is usually
698 used to communicate information from the election organisers to those providing the election service.

699 The message therefore provides information about the election event, all elections within that event and
700 all contests for each election.

701 For the election event, the information includes the ID and name of the event, possibly with a qualifier on
702 the event. This qualifier is used when an event has several local organisers. For example, for a UK
703 general election, each constituency organises its own contests. The election event is therefore the
704 general election, whilst the qualifier would indicate the constituency. Other information regarding an
705 election event comprises the languages to be used, the start and end dates of the event, potentially a list
706 of external documents that are applicable (such as the rules governing the election), a description and
707 information about the managing authority.

708 The managing authority can be indicated for the event, each election, each contest within the election and
709 each reporting unit.

710 An election can have a number of dates associated with it. For example, there is likely to be a period
711 allowed for nomination of candidates and a date when the list of eligible voters is fixed. Each date can be
712 expressed as a single date when something happens, a start date, an end date, or both start and end
713 dates. These dates can be either just a date or both a date and time using the subset of the ISO 8601
714 format supported by XML Schema.

715 Like the event, an election can have both a managing authority and referenced documents. Finally, there
716 is a `Messages` element for additional information.

717 A contest has a name and ID. It can also have reporting unit identifiers. A contest may need to specify its
718 geographical area independently from its name, for which purpose the `Area` element is provided. Each
719 contest can specify the voting channels allowed. In general, the list of possible channels will be further
720 restricted as part of a local customisation. Each channel can specify several methods for authenticating
721 the voter, such as PIN and password, and a response method, indicating the type of response to be given
722 to a cast vote. Finally, facilities are provided to indicate the dates and times when the channel will be
723 available to the voter.

724 As described previously, a contest can indicate its managing authority. It may also indicate the position
725 (such as 'President') for which votes are being cast. The `Description` allows for additional text describing
726 the contest. Each contest indicates the voting method being used, whilst the `CountingAlgorithm`
727 indicates the method of counting (such as the d'Hondt or Meeks method) that will be used. The minimum
728 and maximum number of votes to be cast by each voter can also be indicated.

729 A list of polling places can be provided. These can be either physical locations for people to go to vote,
730 postal addresses for postal votes or electronic locations. An 'other location' is also allowed for cases
731 where these do not meet the requirements. A location can also say when it will be available. This is
732 intended for mobile polling stations that will only be available at a given address for a part of the voting
733 period.

734 Finally, a `Messages` element allows for additional information that might be communicated to the voter
735 later through other messages.

736 Additional Rules

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

737

738 Response (130)

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

742 The message includes information to identify the message to which the response applies (by using the
743 same transaction id in the `EML` element and, if necessary, including the sequence number of the message
744 to which the response applies in the `Response` element), with information on the entity raising the
745 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
750 be in a different format, such as a line number.

751 Note that a single response can be raised for a series of sub-messages with the same transaction ID.
752 This allows indication, for example, that a sub-message was missing.

753 **Additional Rules**

Error Code	Error Description
3130-001	If the message is not accepted, there must be an <code>Errors</code> element

754 **GeoDistrict (150)**

755 This schema allows the use of geographic mapping systems to describe election districts and their
756 boundaries by providing information to voters to help their understanding of where and when they should
757 go to cast their vote. For example information relating to the streets and polling places within a district, the
758 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.

760 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
762 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.

764 This set of authorized information can be made available by any number of organisations through a
765 variety of different outlets.

766 **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.

772 Candidate consent can be combined in a single message with a nomination of the candidate or party or
773 sent separately.

774 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
776 information about the candidate and one or more proposers. The candidate must supply a name.
777 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.

780 The proposers use the standard proposer declaration with a mandatory name and optional contact
781 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
783 party list can also be provided.

784 Candidates, either individuals or on a party list, must define the action being taken and may provide
785 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.

789 **Response to Nomination (220)**

790 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
793 affiliation can be included and a remark explaining the decision.

794 **Additional Rules**

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)**

796 This schema is used for messages transferring candidate lists for specified contests. It has the election
797 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.

801 **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.

804 There is the facility for the transmission channel (for example a trusted web site) to add the time of
805 transmission.

806 **Additional Rules**

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

807 **Election List (330)**

808 This schema is primarily used for messages communicating the list of eligible voters for an election or set
809 of elections. It can also be used for any other purpose that involves the transfer of voter information.
810 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
813 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
 818 voter can have a Blocked element set against them with an optional Reason and Channel. This allows a
 819 list to be produced for a polling place indicating those that have already voted by another means or who
 820 have registered for a postal vote. It can also be used if the complete electoral register must be transmitted
 821 (perhaps as a fraud prevention measure) but some people on the register are no longer eligible to vote.

822 **Additional Rules**

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.

823 **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
 832 Internet voting, phone number for SMS voting etc) and the times that votes can be placed. Use of the
 833 DisplayOrder attribute on these allows the display or printing of information to be tailored from within the
 834 XML message.

835 Ballot information may be included if required. This is a subset of the information defined in the 410-
 836 ballots schema. In this case, it is likely that the short code for a candidate will be used for SMS voting. It is
 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.

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

840 This schema provides a common structure for communications to the voter. Individual message types can
 841 be designed based on extensions of this schema.

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.

846 The identifiers for the election event, election and contest are optional. There is then an element in which
 847 a message can be placed in any of several different formats according to the channel being used.

848 **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.

851 The voter's name must be provided and there can be one or more identifiers. These are shown as a
852 restriction of the `VoterIdentificationStructure`, the restriction being to leave out the `VToken` and
853 `VTokenQualified`. 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.

857 **Internal Generic (350c)**

858 This schema provides a common structure for communications between those involved in organizing an
859 election. Individual message types can be designed based on extensions of this schema.
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.
862 The identifiers for the election event, election and contest are optional. There is then an element in which
863 a message can be placed in any of several different formats according to the channel being used.

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
866 schema 350a. A message conforming to this schema will include a list of allowed channels, either to
867 request general preferences or for a specific election event or election within the event.

868 **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)**

873 This schema is used for messages presenting the ballot to the voter or providing a distributor with the
874 information required to print or display multiple ballots.
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.
877 In other cases, the full information about the elections will be sent with either an election rule ID to identify
878 the voters to whom that election applies or a set of voter names and contact information. If the ballot is
879 being sent directly to the voter, this information is not required. Since printed ballot papers are likely to
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
885 candidate, an affiliation (possibly with a list of candidates) or a referendum proposal. There is also a set of
886 optional information that will be required in some circumstances. Some of this is for display to the voter
887 (`HowToVote` and `Messages`) and some controls the ballot and voting process (`Rotation`,
888 `VotingMethod`, `MaxVotes`, `MinVotes`, `MaxWriteIn`).

889 **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

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

898 **Authentication Response (430)**

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

902 **Cast Vote (440)**

903 This message represents a cast vote, which comprises an optional voting token (which may be qualified)
904 to ensure that the vote is being cast by an authorized voter, information about the election event, each
905 election within the event and the vote or votes being cast in each election, an optional reference to the
906 ballot used, the identifier of the reporting unit if applicable and a set of optional audit information.

907 For each election, the contest is identified, with a set of, possibly sealed, votes. The votes are sealed at
908 this level if there is a chance that the message will be divided, for example so that votes in different
909 elections can be counted in different locations.

910 The selection of candidates, affiliations or a referendum option uses the `Selection` element. If an
911 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.

916 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 `CandidateIdentifier` 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.

926 **Vote Confirmation (450)**

927 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.

931 **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
935 example, because a voter has chosen to spoil a ballot paper, many authorities will want to count that vote

936 as having been cast. The `UncountedVotes` element is reserved for those cases where that record is not
937 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
940 objected to this vote being rejected or the proposal that it should not be counted.

941 **VToken Log (470)**

942 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
944 voted or unvoted for the `VToken` and voted, unvoted and withdrawn for the `VTokenQualified`. In
945 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
949 a complete new log. The logging system can also be identified for audit purposes.

950 **Audit Log (480)**

951 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.

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

	<i>Originating Device</i>	<i>Gateway</i>	<i>Voting System</i>	<i>Counting System</i>	<i>Vtoken Logging System</i>	<i>Seal Logging System</i>	<i>Other</i>	<i>Notes</i>
130								4
410	next receiver	receiver	sender					
420	previous sender	sender	receiver					
430	next receiver	receiver	sender				sender / receiver	3
440	previous sender	sender	receiver					
445	previous sender	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:

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 particular, if an audit 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.

959

960

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

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

971 **Count (510)**

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

975 The message includes the election event identifier, and for each election, the election identifier, an
976 optional reference to the election rule being used and information concerning the set of contests.

977 In some cases, reporting for a contest may be required at a lower level (for example, for each county in a
978 state). For this reason, reporting may be done at the level of the reporting unit, the total votes, or for a
979 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
981 votes that each voter could cast. The key information is that about the votes cast for each of the choices
982 available and the numbers of abstentions and rejected and uncounted votes. If a vote is rejected, for
983 example, because a voter has chosen to spoil a ballot paper, many authorities will want to count that vote
984 as having been cast. The `UncountedVotes` element is reserved for those cases where that record is not
985 required, for example when the result is thought to be fraudulent. Both the `UncountedVotes` and
986 `RejectedVotes` elements have `Reason` (optional) and `ReasonCode` (mandatory) attributes to indicate
987 why the votes were treated as they have been. The former is a textual description, and the latter a code.

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
993 a preference for candidates within the party, the `AffiliationIdentifier` element is used, and multiple
994 `CandidateIdentifier` elements may be used, each with a `Count` attribute. This count is the result of
995 whatever algorithm has been used to calculate the ranking of the candidates.

996 This schema allows for Simulation and Extrapolation of Counts and subsequently Results. Simulation
997 being the facility to forecast the result of a contest based on the result of another contest. Extrapolation is
998 the facility to forecast the final result of a contest based on the count so far.

999 **Result (520)**

1000 Messages described by this schema can be used to communicate the results of simple election types.
1001 One specific use is to provide an input into the calculation algorithm for elections using the additional
1002 member system.

1003 The main part of the schema is held within the `Selection` element. This allows a choice of candidate,
1004 affiliation or referendum option identifiers to be defined with the position that choice achieved (first,
1005 second etc). Optionally, the number of votes can be shown. A candidate can be associated with his or her
1006 affiliation if required. Write in candidates will be shown in the same way as other candidates, although
1007 they will only have an `Id` attribute if this is assigned in the election system after the votes are cast.

1008 This schema allows for Simulation and Extrapolation of Results using data from Counts. Simulation being
1009 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.

1011 **Statistics (530)**

1012 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
1014 district and county level or by which voting channels have been used.

1015 The statistics can be made available through any type of outlet be it Web, TV, SMS etc. and to any type
1016 of organization eg news agencies, political parties.

1017 **Options Nomination (610)**

1018 This schema is used to submit proposals, for example for a referendum or company AGM. It uses the
1019 generic Proposal element to define the proposal itself. One of more proposers can be named and may
1020 sign the nomination.

1021 **Options Nomination Response (620)**

1022 This message is sent from the election organiser to the proposer to say whether the nomination has been
1023 accepted. Along with the acceptance information and the basic information of election, contest and
1024 identifier for the proposal, a remark can be made explaining the decision.

1025 **Additional Rules**

Error Code	Error Description
3620-001	If the nomination has not been accepted, a reason for rejection is required in the <code>Remark</code> element

1026 **Options List (630)**

1027 This schema is used for messages transferring lists of proposals for a referendum. It may identify the
1028 election event, and provides details about the election. Each proposal in a referendum counts as an
1029 election, so each election identified will hold a single proposal.

1030

1031 **6. Conformance**

1032 To conform to this specification, a system must implement all parts of this specification that are relevant to
1033 the interfaces for which conformance is claimed. The required schema set will normally be part of the
1034 conformance criteria and should indicate schema version numbers. For example, the specification for an
1035 election list system might specify that a conforming system must accept and generate XML messages
1036 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
1038 accompanying schemas.

1039

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1055

B. Other Considerations

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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 without regard for system security at all.

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This discussion is included here simply to show how the information passed through the various interfaces described in these standards could be secured and used to help meet some of the requirements commonly found in some elections scenarios.

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Basic Security Requirements

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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:

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- Security considerations of e-voting systems include:

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- Authentication

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- Privacy/Confidentiality

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- Integrity

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- Non-repudiation

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Authentication

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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?”

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1078

There are two aspects of authentication in e-voting systems:

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- Checking a claim of identity

1080

- Checking a right to vote.

1081

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.

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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).

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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, employee ID, Passport etc, all of this can be termed a physical 'credential'. This is often done at the time an electoral register is set up, which can be well before the actual ballot takes place.

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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.

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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:

1098 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
1100 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
1103 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.

1107 Finally, when counting and auditing votes it is necessary to be able to check that the votes were placed
1108 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.

1112 **Privacy/Confidentiality**

1113 This is concerned with ensuring information about voters and how votes are cast is not revealed except
1114 as necessary to count and audit the votes. In most cases, it must not be possible to find out how a
1115 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.

1120 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
1123 means of protecting the voting systems.

1124 Furthermore, the results of voting should not be accessible until the election is complete. Potential
1125 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.

1128 **Integrity**

1129 This is concerned with ensuring that ballot options and votes are correct and unaltered. Having
1130 established the choices within a particular ballot and the voter community to which these choices apply,
1131 the correct ballot information must be presented to each voter. Also, when a vote is placed it is important
1132 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
1135 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.

1141 **Non-Repudiation**

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
1145 provides some level of assurance that the identified participant is not able to successfully assert that the
1146 actions attributed to them via the identification mechanism were, in fact, performed by someone else. The
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
1151 example, approved candidate lists should be verified as having come from an authorized election worker,
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
1156 data can be very reliably attributed to the holder of the private key(s), and can be shown to be
1157 subsequently unmodified. The policy behind the acceptance of these properties, however, must be very
1158 clear about the responsibilities of the private key holders and the required procedures for reporting lost or
1159 stolen private keys. Further, and especially in “mixed-mode” elections (where voters can chose between
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**

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 a contest.
- 1174 • VToken Qualified: the means by which a VToken can be qualified. The reason for the qualification is
1175 always appended to a VToken that is qualified. For example, a qualified VToken may be issued to a
1176 challenged voter.
- 1177 • Vote sealing: the means by which the integrity of voting data (ballot choices, vote cast against a given
1178 VToken) can be protected (e.g. using a digital signature or other authentication code) so that it can be
1179 proved that a voter's authentication and one or more votes are related.

1180 **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

- 1187 • The voting system must be accountable and auditable
- 1188 • Information used to authenticate the voter or his/her right to vote should be protected against misuse
- 1189 (e.g. passwords should be protected from copying)
- 1190 • Voter privacy must be maintained according to the laws of the election jurisdiction. (Legal
- 1191 requirements of public elections in various countries conflict. Some countries require that the vote
- 1192 cannot be tracked back to the voter's identity, while others mandate that it must be possible to track
- 1193 every vote to a legitimate voter's identity)
- 1194 • The casting options available to the voter must be genuine
- 1195 • Proof that all genuine votes have been accurately counted.
- 1196 There are some specific complications that arise with respect to security and electronic voting that
- 1197 include:
- 1198 • Several technologies may be employed in the voting environment
- 1199 • The voting environment may be made up of systems from multiple vendors
- 1200 • A voter may have the option to vote through alternative delivery channels (i.e. physically presenting
- 1201 themselves at a polling station, by post, by electronic means)
- 1202 • The voting systems need to be able to meet various national legal requirements and local voting rules
- 1203 for both private and public elections
- 1204 • Need to verify that all votes are recorded properly without having access to the original input
- 1205 • The mechanism used for voter authentication may vary depending on legal requirements of the
- 1206 contest, the voter registration and the e-voting systems for private and public elections
- 1207 • The user may be voting from an insecure environment (e.g. a PC with no anti-virus checking or user
- 1208 access controls).
- 1209 In addition, the objectives of security architectures for electronic voting systems should include:
- 1210 • Being open
- 1211 • Not restricting the authentication mechanisms provided by e-voting systems
- 1212 • Specifying the security characteristic required of an implementation, allowing for freedom in its
- 1213 precise implementation.
- 1214 • Providing the means to exercise security isolation and controls at interfaces between various election
- 1215 processes, thereby providing the ability to implement isolated trusted logic processes to meet
- 1216 dedicated functions of an election service. Process security isolation ensures that one voting sub-
- 1217 process does not inadvertently effect another voting sub-process thereby undermining the whole
- 1218 voting system.

1219 **Security Architecture**

1220 The architecture proposed here is designed to meet the security requirements and objectives detailed

1221 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
- 1225 • Protecting exchanges with remote voters
- 1226 • Validating Right to Vote and contest vote sealing
- 1227 • Vote confidentiality.
- 1228 • Candidate list Integrity

- 1229 • Vote counting accuracy
- 1230 • Voting system security controls.

1231 **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
1237 meet specific legal requirements, private or public election systems and contest rules. The voter registration
1238 system may interact with the e-voting system and other systems to define how to authenticate a voter for
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
1242 right to vote to the voting system in a contest. Depending on national requirements or specific voting
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.

1247 **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
1272 vote has been altered in any way and that all the votes counted in a contest were valid when audited.

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
1275 qualified with a reason. In this document this is called a VToken Qualified. Before a vote is considered

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

1278 **Protecting exchanges with remote voters**

1279 The VToken may be generated as part of the registration system, the e-voting system, or as interaction
1280 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
1284 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.

1288 Wherever technically possible the exchange of information should be secured and integrity guaranteed
1289 even if non-secure communications channels are used.

1290 **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
1292 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:

- 1296 • The vote cannot be altered from the voter's intention
- 1297 • The voting system is accountable and auditable.

1298 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.
1300 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
1302 time that the vote was cast must be included in the seal, so that they may be checked for validity before
1303 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
1305 also needed of the allocation of a VToken to a voter's identity. Such systems also provide non-repudiation
1306 of the voter's actions. In such cases a voter cannot claim to have not voted or to have voted a different
1307 way, or that his vote was not counted. In many election scenarios where this type of auditing is required, it
1308 must not be easy to associate a VToken to the Voter's identity, therefore this type of records must be
1309 under strict control and protected by security mechanism and procedures, such as; encryption, key
1310 escrow and security operating procedures.

1311 **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
1315 mechanisms) to encryption of the data, with key escrow tools.

1316 **Candidate List integrity**

1317 To ensure that the voter is present and that the candidate list is genuine, there must be a secure channel
1318 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
1322 ballot/vote delivery channel.

1323 As an example, there may be a secure path to convey the VToken to the person entitled to vote, a way of
1324 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.

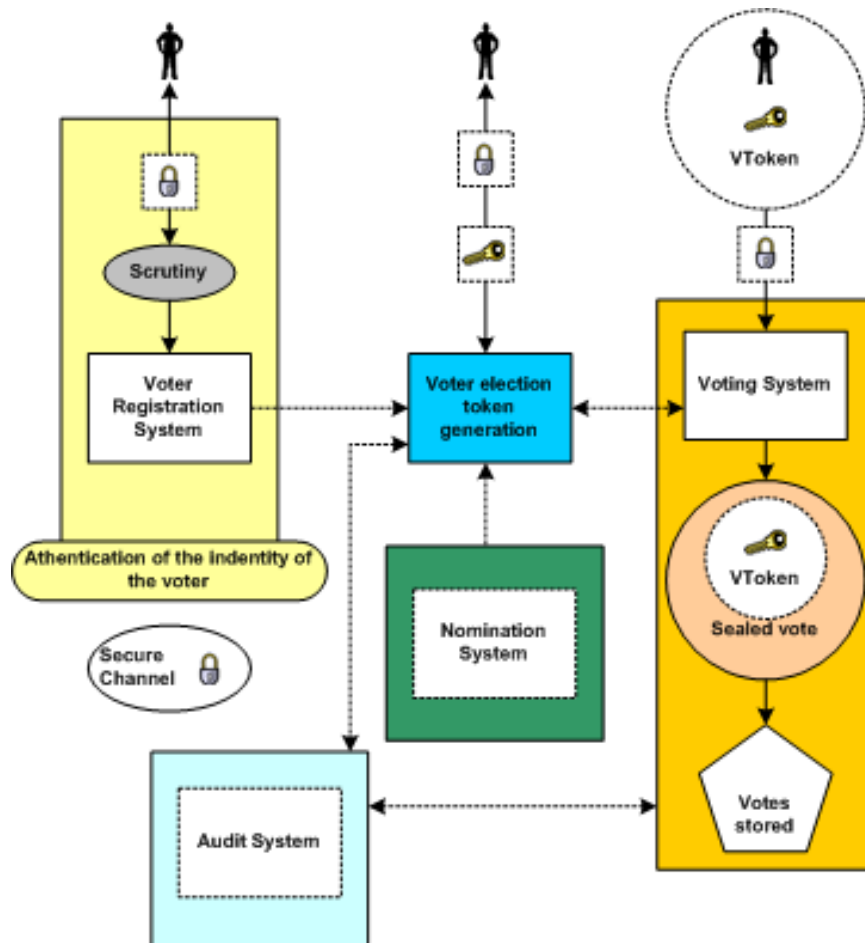
1326 In summary, there must be a way of ensuring the validity of the ballot options and voter selection.

1327 **Vote counting accuracy**

1328 Audit of the system must be able to prove that all vote casts were genuine and that all genuine votes
1329 were included within the vote count. Voters may need to be able to exercise that proof should they so
1330 desire. Thus auditing needs data that has non-repudiation characteristics, such as the VToken/vote
1331 sealing, see schema 470 and 480.

1332 **Voting System Security**

1333 The overall operation of the voting systems and its physical environment must be secure. Appropriate
1334 procedural, physical and computing system controls must be in place to ensure that risks to the e-voting
1335 systems are met. There must be a documented security policy based upon a risk analysis, which
1336 identifies the security objectives and necessary security controls.



1337
1338 **Figure 3A: Voting system security**

1339 **Remote voting security concerns**

1340 Many new election systems are currently under evaluation. These systems tend to offer deployment
 1341 options in which the communication between the voter and the election officials is carried out in an
 1342 environment that is not completely under the control and monitoring of the election officials and/or
 1343 election observers (e.g., the Internet, private network, telephones, cable TV networks, etc.). In these
 1344 'remote' or 'unattended' environments, several particular security concerns and questions like:

- 1345 • How do I know that the candidate information I am being presented with is the correct
 1346 information?
- 1347 • How do I know that my vote will be recorded properly?
- 1348 • How do I know there isn't a man-in-the-middle who is going to alter my vote when I place it?
- 1349 • How do I know that it is the genuine e-voting server I'm connected to that will record my vote rather
 1350 than one impersonating it that's just going to throw my vote away?
- 1351 • How do I know that some component of the system does not have malicious software which will
 1352 attempt to alter the ballot choices as represented to me or alter my election?

1353 The type and importance of a particular contest will have an effect on whether the above concerns exist
 1354 and whether they do, or do not, represent a tangible threat to the voting process and its outcome. The
 1355 table listed at Appendix B2 shows the concerns that have been identified as possibilities for one such
 1356 remote or unattended environment (the Internet) that could be used in public election voting scenarios.
 1357 The table shows how the concerns can be translated to technical threats and characterizes security
 1358 services that may be used to counter such threats. Many of the items are not unique to the Internet, and
 1359 can serve as a useful reference or starting point in developing similar threat analysis for other digital
 1360 and/or unattended voting environments. How the security services are implemented in any particular
 1361 environment or deployment is outside the scope of this document allowing freedom to the system
 1362 providers.

1363

1364 **B.2 Internet Voting Security Concerns**

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

	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	<p>Obtaining the right to vote illegally from a legitimate voter.</p> <p>This may be by intimidation, theft or by any other means by which voting right has been obtained illegally.</p> <p>For example, by</p> <p>Stealing a voting card from a legitimate voter.</p>	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.
		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: Point to point authentication
		Inadequate authentication of voting casting point (e.g. polling station/ballot box)	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
			Integrity of cast votes
		Given to the user	
		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 properly	Integrity of the voting system	Non-repudiation of the vote
			Non-repudiation the vote was cast by a genuine voter
			Audit of voting system
			Connection confidentiality
		Insecure channel between the voter and the vote casting point	Connection Integrity
			Connection Confidentially
		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 can alter my ballot	Vulnerable client environment;	Physical security
		Trojan horses	Procedural security
		Virus	Unpredictable Coded voting 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 accountable and auditable		Non-repudiation of vote data.
			Audit tools
17	Identification and authentication information to and from the voter must be privacy protected	Loss of privacy	Channel to provide: Connection Confidentiality

18	The voter's actual identity may need to be anonymous	Voter's identification is revealed Denial of service attack	Voter's identification is anonymous
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.

1365

1366 **B.3 The Timestamp Schema**

1367 Although used as part of EML, this schema has been put in a separate namespace as it is not an integral
 1368 part of the language. A time-stamp binds a date and time to the sealed data. The time-stamp seal also
 1369 protects the integrity of the data. The structure of the time-stamp is similar to the structure of an XML
 1370 Signature.

1371 The timestamp structure may be used in one of two ways either:

- 1372 • Using Internet RFC 3161 binary encoded time-stamp token with the time-stamp information repeated
 1373 in XML,
- 1374 • 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:

- 1376 • within TimestampedInfo:
- 1377 • TSTOrSignatureMethod identifies RFC 3161.
- 1378 • Reference contains the URI reference of the voting data being time-stamped. The DigestValue sub
 1379 element contains the digest of the voting data being time-stamped.
- 1380 • TSTXMLInfoReference is not present in this case.
- 1381 • SignatureOrTSTValue holds the RFC 3161 time-stamp token applied to the digest of
 1382 TimestampedInfo. The TimestampedInfo is transformed to a canonical form using the method
 1383 identified in CanonicalizationMethod before the digest algorithm is applied.
- 1384 • KeyInfo contains any relevant certificate or key information.

1385 Object contains the TSTXMLInfo element which is a copy of the information in SignatureOrTSTValue
 1386 converted from RFC 3161 to XML encoding. The TSTXMLInfo element contains:

- 1387 • the version of time-stamp token format. This would be set to version 1
- 1388 • the time-stamping policy applied by the authority issuing the time-stamp,
- 1389 • the time-stamp token serial number,
- 1390 • the time that the token was issued, the contents of this element indicate the time of the timestamp.

- 1391 • optionally an indication as to whether the time-stamps are always issued in the order that requests
- 1392 are received
- 1393 • optionally a nonce² given in the request for the time-stamp token,
- 1394 • 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,
- 1397 • TSTOrSignatureMethod identifies the algorithm used to create the signature value.
- 1398 • Reference contains the URI reference of the voting data being time-stamped. The DigestValue sub
- 1399 element contains the digest of the voting data being time-stamped.
- 1400 • TSTXMLInfoReference must be present, and contains the URI reference of TSTXMLInfo as
- 1401 contained within the Object element. The DigestValue sub element contains the digest of the
- 1402 TSTXMLInfo.
- 1403 • SignatureOrTSTValue contains the signature value calculated over the TimestampedInfo using the
- 1404 signature algorithm identified in TSTOrSignatureMethod having been transformed to a canonical form
- 1405 using the method identified in CanonicalizationMethod. This signature is created by the time-stamping
- 1406 authority.
- 1407 • KeyInfo contains any relevant certificate or key information.
- 1408 Object contains the XML encoded time-stamp information in an TSTXMLInfo element. The contents of
- 1409 TSTXMLInfo is the similar as for the case described above. However, in this case the information is
- 1410 directly signed by the time-stamping authority. The TSTXMLInfo element contains:
- 1411 • version of time-stamp token format: This would be set to version 2
- 1412 • the time-stamping policy applied by the authority issuing the time-stamp,
- 1413 • the time-stamp token serial number,
- 1414 • the time that the token was issued, this is the time of the timestamp.
- 1415 • optionally an indication as to whether the time-stamps are always issued in the order that requests
- 1416 were received
- 1417 • optionally a nonce given in the request for the time-stamp token,
- 1418 • optionally the identity of the time-stamping authority.

1419 **B.4 W3C XML Digital Signature**

- 1420 Some information on the digital signature is included here, but for full information refer to the
- 1421 Recommendation at <http://www.w3.org/TR/xmlldsig-core/>
- 1422 An XML Signature consists of:

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

- 1423 • SignedInfo which includes a sequence of references to the data being signed with the digest (eg.
1424 SHA-1 hash) of the data being signed
- 1425 • SignatureValue which contains the signature value calculated over the SignedInfo using the signature
1426 algorithm identified in SignatureMethod having been transformed to a canonical form using the
1427 method identified in CanonicalizationMethod
- 1428 • KeyInfo contains any relevant certificate or key information.
- 1429 • Object can contain any other information relevant to the signature

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C. Processing using Schematron or CAM

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This section gives a short introduction to how validation can be achieved using either Schematron schemas or the OASIS CAM template approach. For Schematron this is done either using an XSLT processor tool (such as Saxon), or by direct validation using the Schematron schemas and a dedicated Schematron processor. For CAM templates this is using a conforming implementation toolkit such as the camprocessor project on SourceForge.net as open source.

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Validation using Schematron Schemas

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A Schematron schema is an XML document that can be converted to XSLT using an XSLT stylesheet.

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There is a published stylesheet (skeleton1-5.xslt) that can be used to achieve this. This produces an HTML output from the validation. A separate stylesheet can be produced that will create an output to the specification below. This stylesheet can import the skeleton and just over-ride those aspects where changes are required.

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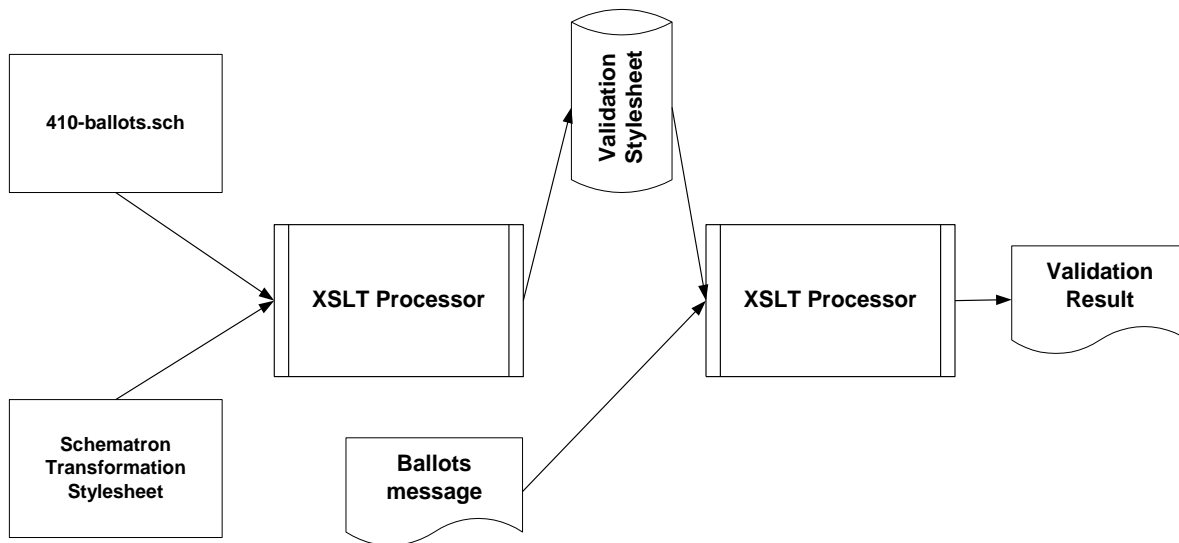
This stylesheet can be used once on each Schematron schema to produce the XSLT file that will be used for validating a specific message type. This stylesheet is then used to transform the incoming EML message into an error report based on the additional constraints.

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The process is shown in the diagram below.



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Validation using OASIS CAM Templates

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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.

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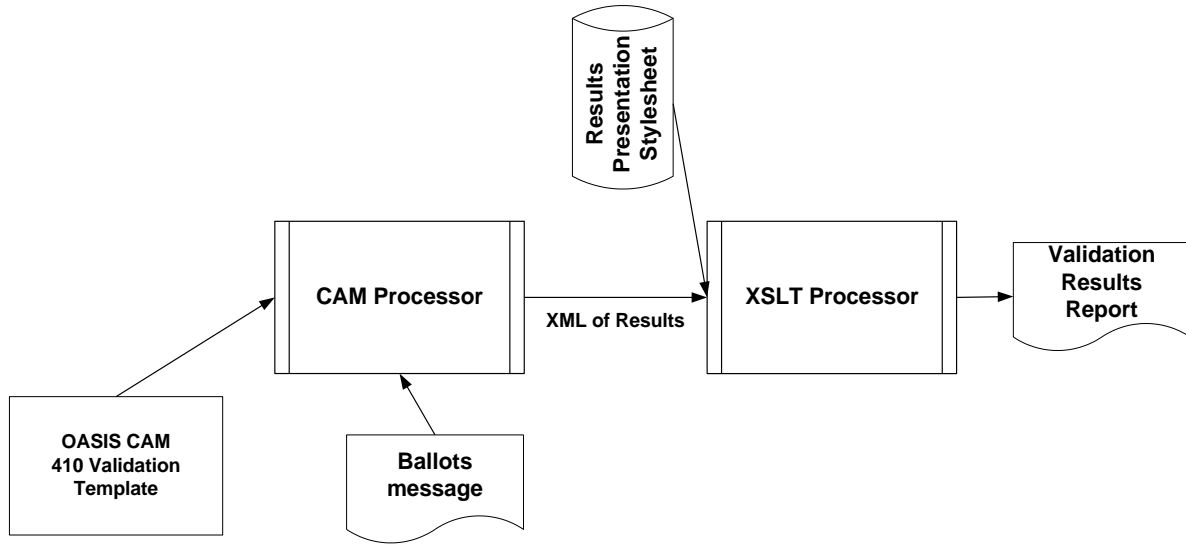
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1458 Once test cases and templates are available then these can be validated using the CAM toolkit. The
1459 process is shown in the diagram below.



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D. Revision History

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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	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 Borrás	Revised draft accommodating requirements of Council of Europe Member States and UK pilots
V4.0b	2004-01-27	J Borrás	Draft Committee Specification
V4.0c	2004-03-09	J Borrás	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 Borrás	Draft Committee Specification for Technical Committee approval.
V4.0	2005-01-24	J Borrás	Committee Specification
V4.0	2006-02-01	J Borrás	OASIS Standard
V5.0	2007-03-14	J Borrás	Committee Draft
V5.0	2007-09-12	J Borrás	Committee Specification
V5.0	2007-12-01	J Borrás	OASIS Standard
V6.0	2009-08-18	J Borrás, D Webber	Committee Draft 01
V6.0	2009-08-18	J Borrás, D Webber	Public Review Draft 01
V6.0	2010-06-11	J Borrás, D Webber	Committee Draft 02
V6.0	2010-06-18	J Borrás, D Webber	Public Review Draft 02

