IPC-2501

Definition for Web-Based Exchange of XML Data (Message Broker)
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- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

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- Increase time-to-market
- Keep people out
- Increase cycle time
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- Contain anything that cannot be defended with data

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IPC-2501

Message Broker – GENERIC

Definition for Web-Based Exchange of XML Data

A standard developed by the CAMX Frameworks Communication Committee (2-50).

The IPC-2501 standard specifies the governing semantics and an XML based syntax for shop floor communication between electronic assembly equipment and associated software applications. Wherever possible, existing and widely accepted protocols have been utilized. Certain guaranteed behaviours have been defined to ensure that mission-critical data is reliably communicated among Clients. The purpose of the standard is to outline the communication architecture, supporting XML messages, and to define the choreography between sender and receiver.

Users of this publication are encouraged to participate in the development of future revisions.

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Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the CAMX Frameworks Communication Committee (2-50) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of the IPC extend their gratitude.

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Definition for Web-Based Exchange of XML Data

Introduction

Information flow is essential to efficient electronics manufacturing and standards are essential to information flow. One area of commerce that has lacked its own communication standards is the electronics manufacturing factory floor. Information exchange between a system of electronic assembly equipment and higher-level applications has, in the past, used proprietary or borrowed standards. The IPC-254X and IPC-255X series of standards address this issue by defining the messages needed for this information exchange.

Just as “snail mail” and e-mail information exchanging requires standards for the envelope and transportation mechanisms – or messaging interface – so also do factory floor communications. This standard describes a messaging interface that is based upon an architecture whereby a single logical middleware server (the Message Broker) exchanges messages among Clients in a Domain.

Clients may be electronics manufacturing equipment or software applications present in the domain. The Message Broker acts as an intelligent message router between these Clients, accomplishing both Point-to-Point and Publish/Subscribe communications. Figure 1 shows a computer-aided manufacturing XML (CAMX) Domain consisting of the Message Broker, Application Clients, and Equipment Clients.

Although the scope of this document is that of electronics manufacturing, the broader applicability of the message transport mechanisms defined by this standard must be noted. Any application that uses XML-based messages can use the IPC-2501 web-based exchange mechanism. Specifically, this standard can support the exchange of XML-based messages both within an enterprise, be it manufacturing or service based -- and externally -- between multiple enterprises having the need for efficient, reliable web-based communications. Broad adoption of this standard is strongly encouraged.

Figure 1  Example IPC-2501 Domain consisting of the Message Broker, Application Clients, and Equipment Clients
1 Scope

The intent of this standard is to establish the governing semantics and an XML based syntax for shop floor communication between electronic assembly equipment and associated software applications. Wherever possible, existing and widely accepted protocols have been utilized. Certain guaranteed behaviors have been defined to ensure that mission-critical data is reliably communicated among Clients.

The purpose of this specification is to outline the communication architecture and supporting XML messages. The required programmatic actions that define the choreography between sender and receiver have also been defined.

The domain of this standard is that of an electronics assembly manufacturing shop, consisting of up to several hundred machines, each of which is capable of producing tens of messages per second. Most of these messages are relatively small in size (under 20 kilobytes); however some application-specific files of several megabytes will occasionally need to be transferred. The number of consumers of this information is assumed to be a relatively small number, typically less than 20, and this number does not directly increase in proportion to the number of machines. Provisions have also been made to accommodate network interruptions.

1.1 General Design Principals

Many different levels of system complexity are possible in addressing the intent outlined above. The industry participants guiding the development of this standard set forth the following design principles:

- Low Cost
- Low Complexity
- Stable
- Deterministic
- Centrally Configured
- Scalable

1.2 Intended Audience

This document is intended for an audience of manufacturing system software developers, computer aided manufacturing application programmers and Information Technology professionals as well as an end user community that includes process engineers and manufacturing specialists.

2 Interpretation

"Shall", the emphatic form of the verb, is used throughout this standard whenever a requirement is intended to express a provision that is mandatory. Deviation from a shall requirement is not permitted, and compliance with the XML syntax and semantics shall be followed without ambiguity, or the insertion of superfluous information. The words "should" and "may" are used whenever it is necessary to express non-mandatory provisions. "Will" is used to express a declaration of purpose.

To assist the reader, the word shall is presented in boldface characters.
3 General Requirements

The XML schemas contained in this document describe the structures for a CAMX data exchange. The document specifies data elements specifically designed to establish the information exchange capabilities as related to the electronics manufacturing factory floor. The XML schemas define the configuration of mandatory and optional elements, as well as mandatory and optional attributes.

3.1 Terms and Definitions

The definitions of all terms used herein shall be as specified in IPC-1050, and by the following:

**Client** – A generic term for any of the various machines, applications, or devices that may connect to a Message Broker in a Domain.

**Domain** - The set of all Clients interested in communicating with each other. It contains a single logical Message Broker and a configurable number of Clients.

**Domain Configuration** - The Domain Configuration defines publishing capabilities, subscription interests, point-to-point communication privileges, quality of service parameters and general information about the Domain.

**Message Broker** - The Message Broker is the messaging middleware. It is responsible for intelligently routing messages among Clients.

3.2 Communication Architecture

In accordance with the intent of using broadly accepted standards where possible, this system makes use of TCP/IP, HTTP, XML, and SOAP as illustrated in Figure 2.

![Figure 2 IPC-2501 Layered Communications Architecture](image)

There are two chief advantages of this standards-based approach. First, re-invention and re-implementation of basic commodity functionality is minimized. Second, the use of widely accepted Internet standards will make the IPC-2501 more attractive to potential implementers.

The way in which SOAP with attachments and the HTTP protocol are used together to represent IPC-2501 messages is illustrated in Figure 3.
3.2.1 TCP/IP Usage

TCP/IP is used by this standard because it is absolutely standardized and offers the highest assurance that all types of systems from all vendors can communicate effectively.

3.2.2 HTTP Usage

All transfers of messages in an IPC-2501 Domain are accomplished via the HTTP 1.1 protocol through the Message Broker. The Message Broker acts as an HTTP Server and the Clients act as HTTP Clients.

A transaction consists of two HTTP transmissions. The first transmission is an HTTP Client Request and shall be initiated by a Client. The second transmission is an HTTP Server Response, and shall be accomplished by the Message Broker (see Figure 4).

The HTTP Client Request shall use the HTTP POST method. The HTTP Server shall Respond with either an HTTP 200 or an HTTP 500 status code. An HTTP 200 status code shall indicate that the HTTP request has succeeded. An HTTP 500 status code shall indicate the Message Broker encountered an unexpected HTTP condition that prevented it from fulfilling the request.

For further information about HTTP 1.1, see:

http://www.w3.org/Protocols/rfc2616/rfc2616.html.
3.2.3 SOAP with Attachments Usage

In addition to HTTP, SOAP with Attachments shall be used to transfer messages. Each HTTP transmission as defined in the previous section shall contain two MIME blocks. The first MIME block shall contain a SOAP Envelope. The second MIME block shall contain the message that is being transferred. (note: Future versions of this standard may use multiple MIME blocks to transfer additional data.)

The SOAP Envelope contains a SOAP Header element and a SOAP Body element. The SOAP Header element shall contain an IPC-2501 MessageInfo as a child element. If a SOAP fault has been generated, the SOAP Body shall contain the SOAP fault (see Figure 5).

For more information about SOAP Version 1.1, see:
http://www.w3.org/TR/SOAP/

For more information about SOAP with Attachments, see:
http://www.w3.org/TR/2000/NOTE-SOAP-attachments-20001211.html

The SOAP 1.1 envelope schema can be found at:
http://schemas.xmlsoap.org/soap/envelope/
3.2.3.1 MessageInfo Element

The MessageInfo element contains meta-level information about the message that is contained in the second MIME block of each HTTP transmission. Attributes of the MessageInfo element provide origination and destination context to the message so that it can be routed appropriately. Attributes are also included that indicate the schema of the message, a unique identifier, and the date and time of the message.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>sender</td>
<td>anyURI</td>
<td>The unique, predefined name of the entity in the Domain sending this message.</td>
<td>1</td>
</tr>
<tr>
<td>destination</td>
<td>anyURI</td>
<td>The unique, predefined name of the entity in the Domain where this message is to be sent.</td>
<td>1</td>
</tr>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The date and time of the message.</td>
<td>1</td>
</tr>
<tr>
<td>messageSchema</td>
<td>anyURI</td>
<td>The location of the schema of the attached message represented by this element.</td>
<td>1</td>
</tr>
<tr>
<td>messageId</td>
<td>string</td>
<td>An attribute representing the unique identifier of the message.</td>
<td>1</td>
</tr>
</tbody>
</table>

URI: [http://webstds.ipc.org/2501/MessageInfo.xsd](http://webstds.ipc.org/2501/MessageInfo.xsd)

Graphic Representation:

Schema:

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema"
    elementFormDefault = "qualified">
    <xsd:element name = "MessageInfo">
        <xsd:complexType>
            <xsd:attribute name = "dateTime" use = "required" type = "xsd:dateTime"/>
            <xsd:attribute name = "sender" use = "required" type = "xsd:anyURI"/>
            <xsd:attribute name = "destination" use = "required" type = "xsd:anyURI"/>
            <xsd:attribute name = "messageId" use = "required" type = "xsd:string"/>
            <xsd:attribute name = "messageSchema" use = "required" type = "xsd:anyURI"/>
        </xsd:complexType>
    </xsd:element>
</xsd:schema>
```

3.2.3.1.1 Unique ID Generation

Each message shall be uniquely identified for the purpose of acknowledgement, logging, response correlation and other purposes. Identifier strings must be printable characters and may be generated in any fashion that will produce an identifier with a name space collision possibility of zero.
Recommended Methods:
Systematic identification can be attained through requests for a 128 bit Globally Unique Identifier (GUID) or Universally Unique Identifier (UUID). Where such identification is not readily available the recommended methodology is to concatenate the sender’s internet protocol (IP) address or networking hardware machine (MAC) address with a string representing the current date, time and time zone. This will typically produce 1/100 second accuracy. Where this is not of sufficient resolution to meet the message generation rate, appending an additional counting sequence is recommended (i.e. "130.207.198.100|20010501013725.85+5000|00").

3.3 Message Transfer
Most all CAMX messages will be exchanged among two or more Clients through the Message Broker. Only messages conveying Domain information will involve just the Message Broker and an individual Client. All messages, including those from one Client to another, shall be sent to the Message Broker. In this respect the Message Broker functions as a publisher, taking a submission from a Client and distributing it to all the Clients that have requested submissions of that type. Unsolicited submissions are not allowed; the Message Broker obtains a list of messages each Client can generate and makes the list of messages available to all Clients. The Message Broker then instructs each Client to generate only those messages to which at least one Client has subscribed.

Under normal operations a Client needs only to send a message once, regardless of the number of subscribers. It is the responsibility of the Message Broker to ensure the message is replicated and delivered to each and every Client who has subscribed to that message. Consuming Clients may receive the messages not in chronological sequence though.

When the Message Broker receives a submitted message it places the message in a first-in-first-out queue and awaits a request for messages from the subscribed Client(s). Each subscribed Client periodically queries the Message Broker as to whether or not there are any queued messages (see 4.4 GetMessage). By this practice, messages will be received by the Client in the sequence that they were received by the Message Broker.

The normal rules here established for publication of messages do not apply to point-to-point communication. A Client, if authorized in the Domain configuration, can send a message to another Client. Such a message might, for example, request information as to the current value of a specific parameter. Such point-to-point messages shall follow the same rules as published messages in that they are sent to the Message Broker who queues the message, completing the delivery only when the receiving Client requests its messages. Sections 3.3.1 to 3.3.4 contain additional details about successfully transferring a message. Section 5 contains guidance for handling errors that might occur when attempting to transfer a message.
3.3.1 Client to Message Broker Transfer

The transfer of a message from a Client to the Message Broker is accomplished via two HTTP transmissions (see Figure 6).

![Diagram](http://example.com/diagram.png)

**Figure 6** The successful transfer of a message from a Client to the Message Broker.

The message was Acknowledged by the Message Broker.

The specifics of the transmissions are as follows:

1. The Client **shall** transmit the message via an HTTP POST request, in which the message to be transferred is included in the second MIME block.
2. The Message Broker **shall** respond with an HTTP 200 status code, and an **Acknowledge** contained in the second MIME block.

3.3.2 Message Broker to Client Transfer

The transfer of a message from the Message Broker to a Client is accomplished via four HTTP transmissions (see Figure 7).

![Diagram](http://example.com/diagram2.png)

**Figure 7** The successful transfer of a message from the Message Broker to a Client
The specifics of the transmissions are as follows:

1. The Client shall transmit an IPC-2501 GetMessage via an HTTP POST request, in which the GetMessage is included in the second MIME block.

2. The Message Broker shall respond with an HTTP 200 status code, and the message to be transferred contained in the second MIME block.

3. The Client shall transmit an Acknowledge via an HTTP POST request, in which the Acknowledge is contained in the second MIME block.

4. The Message Broker shall respond with an HTTP 200 status code, and an empty SOAP envelope.

If no messages are queued by the Message Broker for the Client, only two HTTP transmissions will take place (see Figure 8).

![Figure 8](image-url)  
**Figure 8** When a message is not waiting for a Client, only two HTTP transmissions take place

The specifics of the transmissions are as follows:

1. The Client shall transmit an IPC-2501 GetMessage via an HTTP POST request, in which the GetMessage is included in the second MIME block.

2. The Message Broker shall respond with an HTTP 200 status code, and an empty SOAP envelope.

3.3.3 Client to Client Transfer (Point-to-Point)

The transfer of a message from one Client to another Client is accomplished through the Message Broker via six HTTP transmissions (see Figure 9).

Note: This Standard enforces single-level, Broker–Client acknowledgement for Point-to-Point messages; End-to-End acknowledgement is not overtly supported.
The specifics of the transmissions are as follows:

1. **Client1 shall** transmit the message via an HTTP POST request, in which the message to be transferred is included in the second MIME block.
2. The Message Broker **shall** respond with an HTTP 200 status code, and an Acknowledge contained in the second MIME block.
3. **Client2 shall** transmit an IPC-2501 GetMessage via an HTTP POST request, in which the GetMessage is included in the second MIME block.
4. The Message Broker **shall** respond with an HTTP 200 status code, and the message to be transferred contained in the second MIME block.
5. **Client2 shall** transmit an Acknowledge via an HTTP POST request, in which the Acknowledge is contained in the second MIME block.
6. The Message Broker **shall** respond with an HTTP 200 status code, and an empty SOAP envelope.

### 3.4 Quality of Service

In the factory floor environment of this standard, the data about the product can be as important as the product itself. Because of this, the industry participants guiding the development of this standard set forth a Quality of Service guideline resulting in the choreography of message queuing, sending, resending and acknowledgement that follows.

#### 3.4.1 Guaranteed Message Delivery

Guaranteed Message Delivery is accomplished by adopting some simple rules aimed at data integrity. The Acknowledge message **shall** be used to indicate when conformance to these rules has been achieved. Because the unlimited application of these data integrity rules could quickly overwhelm the message storage capabilities of the nodes within the IPC-2501 domain, Quality of
Service terms (data integrity rules) can be applied to bound the message storage used by IPC-2501 data for both the Client and the Message Broker. Each of these concepts is described in greater detail in the sub-sections below.

3.4.2 Data Integrity

Data to be published is initially the responsibility of the producing Client and remains its responsibility until such time as it sends the data as an IPC-2501 message AND receives an Acknowledgement of receipt of the message from the Message Broker. Only at that time has the Client passed responsibility for the data exchange to the Message Broker. Until that time a copy of the data shall remain with the Client in non-volatile media.

The Message Broker shall be responsible for the message data until such time as the Message Broker has passed a copy of the message to all Clients that have subscribed to that message type from the producing Client, AND received an Acknowledgement of receipt of the message from each of these Clients. Until that time a copy of the data shall remain with the Message Broker in non-volatile media.

3.4.3 Acknowledge

Acknowledge is a response from either the Message Broker to a Client or vice-versa indicating receipt and acceptance of data.

A Client SHALL NOT transmit a new message until the Message Broker has acknowledged the previous message. The Message Broker SHALL NOT transmit a new message to a particular Client until that Client has acknowledged the previous message.

Acknowledge specifically does not indicate application level cognizance of the message. It does not provide any assurance that the message payload was syntactically correct, was understood, or was agreed to by the recipient. Message Broker Acknowledge does not imply that the message has reached its intended recipient. All messages shall be acknowledged with the following exceptions:

1) Acknowledge messages themselves are not acknowledged
2) Error messages are not acknowledged
3) The empty response (i.e. “no messages queued”) to a GetMessage request is not acknowledged

3.4.4 Queue Full Operation

Since media is finite, the non-volatile memory allocated by the Message Broker for a Client may become full. There are two permissible policies for storage overflow: loss and loss-less. These policies are indicated respectively by ERASE and STOP values in the queueFullOperation attribute of the DomainConfiguration. A QueueFull condition is defined as a queue that contains the maximum number of messages that it can store as specified by the queueSizeAttribute of the Client element, see Section 4.2.4.

The loss policy (indicated by an attribute value of ERASE) permits the discarding of sufficient messages from non-volatile memory to resume operations.

The loss-less policy (indicated by an attribute value of STOP) only allows the discard of messages held for a Client via human intervention (including a domain change). If Message Broker persistent media resources are insufficient to store incoming messages, all such incoming messages are refused (i.e., NOT Acknowledged) until such time as confirmed delivery of
currently persisted messages frees up sufficient non-volatile memory to resume server operations.

Note that these rules as described above establish a delivery policy of *at least once*, meaning if a communication between Message Broker and Client is interrupted before a message exchange transaction is complete, then the initiating party will resend the message. If the interruption results in a corruption of the acknowledgement rather than the message transmission, these rules will result in a duplicate copy of the message arriving at the destination. All 2501 Clients must therefore be tolerant to duplicate messages as identified by the messageld attribute.

### 3.5 Domain Configuration

The Domain is configured “statically,” or more specifically, externally to the IPC-2501 message exchange process by an Administrator. The DomainConfiguration schema listed in Section 4.2 provides a list of what options may be configured.

It is recommended that all Clients begin message transfer within the Domain by sending the Message Broker an initial GetDomainConfiguration message, to assure the Client is communicating with the intended broker in the intended domain. If the Client is not listed in the Domain Configuration, an Error will be generated (see Section 4.6 Error for a complete list of error codes).
4 IPC-2501 Messages

Many functions of the 2501 Domain (such as event notification, persistence, and status retrieval) are controlled via XML messages carried as MIME attachments to the SOAP envelope. The following sections document the information models (schemas) of these messages.

4.1 GetDomainConfiguration

This message is sent by a Client to the Message Broker to obtain the current DomainConfiguration.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The time stamp capturing the instant the Client created the GetDomainCharacteristics message.</td>
<td>1</td>
</tr>
<tr>
<td>domainName</td>
<td>string</td>
<td>The name of the Domain that the Message Broker is servicing.</td>
<td>1</td>
</tr>
<tr>
<td>Extensions</td>
<td>Element</td>
<td>An optional element for containing non-standard XML messages and references.</td>
<td>0-1</td>
</tr>
</tbody>
</table>

¹Occurrence

URI: http://webstds.ipc.org/2501/GetDomainConfiguration.xsd

Graphical Representation:

```
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema"
  xmlns:soap = "http://schemas.xmlsoap.org/soap/envelope/"
  xmlns:ext = "http://webstds.ipc.org/2501">
  <xsd:element name = "DomainConfigurationChange">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref = "Extensions" minOccurs = "0"/>
      </xsd:sequence>
      <xsd:attribute name = "dateTime" use = "required" type = "xsd:dateTime"/>
      <xsd:attribute name = "domainName" use = "required" type = "xsd:string"/>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name = "Extensions">
    <xsd:complexType/>
  </xsd:element>
</xsd:schema>
```
4.2 DomainConfiguration

The DomainConfiguration defines the configuration of the Domain. It specifically defines the following:

- The publishing capabilities of all Clients and the Message Broker
- The subscription interests of each Client
- The point-to-point messages that the Message Broker will deliver to each Client
- Quality of service information
- General information about the Domain

The DomainConfiguration is returned to a Client in response to a GetDomainConfiguration message.

Individual elements of the schema are described in Sections 4.2.1 to 4.2.7. The comprehensive DomainConfiguration schema is listed in the Section 4.2.8.

4.2.1 DomainConfiguration Element

The root element of the DomainConfiguration schema is the DomainConfiguration element. Information about the Message Broker is contained in the Broker sub-element and information about the Clients is contained in the ClientList sub-element. The attributes contain general information about the domain.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>domainName</td>
<td>string</td>
<td>The name of the Domain that the Message Broker is servicing.</td>
<td>1</td>
</tr>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The time and date when the DomainConfiguration was created or last modified.</td>
<td>1</td>
</tr>
<tr>
<td>author</td>
<td>string</td>
<td>The author of the DomainConfiguration</td>
<td>1</td>
</tr>
<tr>
<td>comments</td>
<td>string</td>
<td>Comments about the DomainConfiguration</td>
<td>1</td>
</tr>
<tr>
<td>Broker</td>
<td>Element</td>
<td>Aggregates information associated with the Message Broker</td>
<td>1</td>
</tr>
<tr>
<td>ClientList</td>
<td>Element</td>
<td>Aggregates Information about all the Clients</td>
<td>1</td>
</tr>
</tbody>
</table>

4.2.2 Broker Element

The Broker Element contains information about the Message Broker. Specifically, the messages that the Message Broker is capable of publishing are contained in the PublishList sub-element, and the name of the Message Broker is contained in the attributes.
4.2.3 ClientList Element

The ClientList element contains one or more Client elements.

4.2.4 Client Element

The Client element contains information about an individual Client. Specifically, the messages that the Client is capable of publishing are contained in the PublishList sub-element, the messages the Client will accept are contained in the ReceiveList sub-element and the messages the Client desires to receive are contained in the SubscriptionList sub-element.
| PublishList | Element | A list of all messages that a Client or the Message Broker is capable of publishing. | 1 |
| ReceiveList | Element | The only messages that the Message Broker will send this Client via Point-to-Point communication. | 1 |
| SubscriptionList | Element | A list of messages the Client desires. | 1 |

### 4.2.5 PublishList Element

The PublishList element contains the list of messages that the Message Broker or Clients are capable of publishing.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>occ^1</th>
</tr>
</thead>
<tbody>
<tr>
<td>MessageSchema</td>
<td>anyURI</td>
<td>A message URI that indicates the schema that corresponds to a message.</td>
<td>0-n</td>
</tr>
</tbody>
</table>

### 4.2.6 ReceiveList Element

The ReceiveList element contains the list of Point-to-Point messages that a Client will accept from other Clients. The messages in the ReceiveList are grouped by sender.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>occ^1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sender</td>
<td>Element</td>
<td>Aggregates information on a per Sender basis.</td>
<td>0-n</td>
</tr>
<tr>
<td>senderName</td>
<td>anyURI</td>
<td>The name of the Sender. A unique URI for each Sender.</td>
<td>1-n if Sender</td>
</tr>
<tr>
<td>MessageSchema</td>
<td>anyURI</td>
<td>A message URI that indicates the schema that corresponds to a message.</td>
<td>1-n</td>
</tr>
</tbody>
</table>
4.2.7 SubscriptionList Element

The SubscriptionList element contains the list of messages that the Client desires to receive from publishing Clients. The messages in the SubscriptionList are grouped by publishing Clients.

| ATTRIBUTE NAME | ATTRIBUTE TYPE | DESCRIPTION | OCC
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Publisher</td>
<td>Element</td>
<td>Aggregates information of a publisher.</td>
<td>0-n</td>
</tr>
<tr>
<td>publisherName</td>
<td>anyURI</td>
<td>The name of a Publishing Client that this Client desires to receive messages from.</td>
<td>1-n if Publisher</td>
</tr>
<tr>
<td>MessageSchema</td>
<td>anyURI</td>
<td>A message URI that indicates the schema that corresponds to a message.</td>
<td>1-n</td>
</tr>
</tbody>
</table>

4.2.8 DomainConfiguration

The comprehensive DomainConfiguration schema.


Schema:

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema">
  <xsd:element name = "DomainConfiguration">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref = "Broker"/>
        <xsd:element ref = "ClientList"/>
      </xsd:sequence>
    </xsd:complexType>
  </xsd:element>
</xsd:schema>
```
<xsd:attribute name="comments" use="required" type="xsd:string"/>
</xsd:complexType>
</xsd:element>
<xsd:element name="Client">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="PublishList"/>
      <xsd:element ref="ReceiveList"/>
      <xsd:element ref="SubscriptionList"/>
    </xsd:sequence>
  </xsd:complexType>
  <xsd:attribute name="clientName" use="required" type="xsd:anyURI"/>
  <xsd:attribute name="queueSize" use="required" type="xsd:integer"/>
  <xsd:attribute name="queueFullOperation" use="required">  
    <xsd:simpleType>
      <xsd:restriction base="xsd:string">
        <xsd:enumeration value="STOP"/>
        <xsd:enumeration value="ERASE"/>
      </xsd:restriction>
    </xsd:simpleType>
  </xsd:attribute>
</xsd:element>
<xsd:element name="SubscriptionList">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="Publisher" minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
<xsd:element name="PublishList">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="MessageSchema" minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
<xsd:element name="ReceiveList">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="Sender" minOccurs="0" maxOccurs="unbounded"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
<xsd:element name="Publisher">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="MessageSchema" maxOccurs="unbounded"/>
    </xsd:sequence>
    <xsd:attribute name="publisherName" use="required" type="xsd:anyURI"/>
  </xsd:complexType>
</xsd:element>
<xsd:element name="MessageSchema" type="xsd:anyURI"/>
<xsd:element name="ClientList">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="Client" maxOccurs="unbounded"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
<xsd:element name="Broker">
  <xsd:complexType>
    <xsd:sequence>
      <xsd:element ref="PublishList"/>
      <xsd:element ref="PublishList"/>
      <xsd:attribute name="brokerName" use="required" type="xsd:anyURI"/>
    </xsd:sequence>
  </xsd:complexType>
</xsd:element>
<xsd:element name="Sender">
  <xsd:complexType>

</xsd:element>
4.3 DomainConfigurationChange

This message indicates that the DomainConfiguration has changed. To obtain the new DomainConfiguration, Clients can send a GetDomainConfiguration to the Message Broker.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The time stamp capturing the instant the Message Broker created the DomainConfigurationChange message.</td>
<td>1</td>
</tr>
<tr>
<td>domainName</td>
<td>string</td>
<td>The name of the Domain that the Message Broker is servicing.</td>
<td>1</td>
</tr>
<tr>
<td>Extensions</td>
<td>Element</td>
<td>An optional element for containing non-standard XML messages and references.</td>
<td>0-1</td>
</tr>
</tbody>
</table>


Schema:
```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema">
  <xsd:element name = "DomainConfigurationChange">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref = "Extensions" minOccurs = "0"/>
      </xsd:sequence>
      <xsd:attribute name = "dateTime" use = "required" type = "xsd:dateTime"/>
      <xsd:attribute name = "domainName" use = "required" type = "xsd:string"/>
    </xsd:complexType>
  </xsd:element>
</xsd:schema>
```
4.4 GetMessage

Clients send this message to the Message Broker to retrieve queued messages stored by the Message Broker for the Client.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The time stamp capturing the instant the Client created the request for Message Broker-side messages.</td>
<td>1</td>
</tr>
<tr>
<td>Extensions</td>
<td>Element</td>
<td>An optional element for containing non-standard XML messages and references.</td>
<td>0-1</td>
</tr>
</tbody>
</table>

URI: [http://www.w3.org/2001/XMLSchema](http://www.w3.org/2001/XMLSchema)

Graphical Representation:

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema">
  <xsd:element name = "GetMessage">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref = "Extensions" minOccurs = "0"/>
      </xsd:sequence>
      <xsd:attribute name = "dateTime" use = "required" type = "xsd:dateTime"/>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name = "Extensions"/>
</xsd:schema>
```
4.5 Acknowledge

Acknowledge is used to confirm the receipt of a message.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The time stamp capturing the instant the Message Broker created the DomainCharacteristics message.</td>
<td>1</td>
</tr>
<tr>
<td>MessageId</td>
<td>Element</td>
<td>An element representing each messages unique ID.</td>
<td>1</td>
</tr>
<tr>
<td>Extensions</td>
<td>Element</td>
<td>An optional element for containing non-standard XML messages and references.</td>
<td>0-1</td>
</tr>
</tbody>
</table>

URI: [http://webstds.ipc.org/2501/Acknowledge.xsd](http://webstds.ipc.org/2501/Acknowledge.xsd)

Graphical Representation:

![Graphical Representation](image)

Schema:

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema">
    <xsd:element name = "Acknowledge">
        <xsd:complexType>
            <xsd:sequence>
                <xsd:element ref = "MessageId"/>
                <xsd:element ref = "Extensions" minOccurs = "0"/>
            </xsd:sequence>
            <xsd:attribute name = "dateTime" use = "required" type = "xsd:dateTime"/>
        </xsd:complexType>
    </xsd:element>
    <xsd:element name = "Extensions"/>  
    <xsd:element name = "MessageId" type = "xsd:string"/>
</xsd:schema>
```
4.6 Error

The Error message is used to communicate that an applications error has occurred. It is generated when the receiver of a message (Client or Message Broker) determines that a message is internally inconsistent, or when the receiver is not able to recognize or resolve the message content. A set of predefined errors must be supported by an IPC-2501 compliant Message Broker.

<table>
<thead>
<tr>
<th>ATTRIBUTE NAME</th>
<th>ATTRIBUTE TYPE</th>
<th>DESCRIPTION</th>
<th>OCC</th>
</tr>
</thead>
<tbody>
<tr>
<td>dateTime</td>
<td>dateTime</td>
<td>The time stamp capturing the instant the Acknowledge message was created.</td>
<td>1</td>
</tr>
<tr>
<td>messageIdReference</td>
<td>string</td>
<td>A reference to the messageId of the problem message.</td>
<td>1</td>
</tr>
<tr>
<td>errorCode</td>
<td>string</td>
<td>A unique value for each error type.</td>
<td>1</td>
</tr>
<tr>
<td>note</td>
<td>string</td>
<td>The description of the error.</td>
<td>0-1</td>
</tr>
<tr>
<td>Extensions</td>
<td>Element</td>
<td>An optional element for containing non-standard XML messages and references.</td>
<td>0-1</td>
</tr>
</tbody>
</table>

URI: http://webstds.ipc.org/2501/Error.xsd

Graphical Representation:

Schema:

```xml
<?xml version = "1.0" encoding = "UTF-8"?>
<xsd:schema xmlns:xsd = "http://www.w3.org/2001/XMLSchema">
  <xsd:element name = "Error">
    <xsd:complexType>
      <xsd:sequence>
        <xsd:element ref = "Extensions" minOccurs = "0"/>
      </xsd:sequence>
      <xsd:attribute name = "dateTime" use = "required" type = "xsd:dateTime"/>
      <xsd:attribute name = "messageIdReference" use = "required" type = "xsd:string"/>
      <xsd:attribute name = "errorCode" use = "required" type = "xsd:string"/>
      <xsd:attribute name = "note" type = "xsd:string"/>
    </xsd:complexType>
  </xsd:element>
  <xsd:element name = "Extensions">
    <xsd:complexType/>
  </xsd:element>
</xsd:schema>
```
## Predefined Error Codes and Notes

<table>
<thead>
<tr>
<th>errorCode</th>
<th>NOTE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO ATTACHMENTS INCLUDED</td>
<td>No attachments were included with request.</td>
</tr>
<tr>
<td>INVALID ENTITY NAME</td>
<td>Your name is not a valid entity in the Domain.</td>
</tr>
<tr>
<td>NOT WELL FORMED XML 2501</td>
<td>The 2501 message transmitted was not well formed XML.</td>
</tr>
<tr>
<td>NOT VALID XML 2501</td>
<td>The 2501 message transmitted was not valid XML.</td>
</tr>
<tr>
<td>TYPE MISMATCH</td>
<td>Message sent was not of the type described in the message header.</td>
</tr>
<tr>
<td>UNRECOGNIZED MESSAGE TYPE 2501</td>
<td>Unrecognized 2501 message type transmitted.</td>
</tr>
<tr>
<td>NO MESSAGE TO ACKNOWLEDGE</td>
<td>You are attempting to acknowledge a message that was not sent to you, has expired in transit, or should not have been acknowledged.</td>
</tr>
<tr>
<td>BAD DOMAIN</td>
<td>This broker is not servicing the requested Domain.</td>
</tr>
<tr>
<td>NO PERMISSION TO PUBLISH</td>
<td>The current Domain configuration does not grant you permission to publish.</td>
</tr>
<tr>
<td>NO PUBLISHING SCHEMA IN DOMAIN</td>
<td>The current Domain configuration does not grant you permission to publish messages of this schema.</td>
</tr>
<tr>
<td>MESSAGEID NOT UNIQUE</td>
<td>Duplicate (non-unique) messageld used to identify a message referencing a different message schema. Message will not be processed.</td>
</tr>
<tr>
<td>UNNECESSARY PUBLISHING</td>
<td>It is not necessary for you to send messages of this schema because no Clients in this Domain have subscribed to the selected schema.</td>
</tr>
<tr>
<td>QUEUE FULL</td>
<td>Your queue has become full; as a result, some messages may have been truncated.</td>
</tr>
<tr>
<td>BAD POINT TO POINT DESTINATION</td>
<td>The destination Client was not found in the Domain</td>
</tr>
<tr>
<td>NO POINT TO POINT PERMISSION IN DOMAIN</td>
<td>The current Domain configuration does not grant permission to send a message of that schema to that Client</td>
</tr>
</tbody>
</table>
5 Process Flow Diagrams.

Section 3.3 outlines the simple choreography of successful message transfer. This section contains non-normative process flow diagrams outlining the decisions to be made by lower level applications, to assist in the development of IPC-2501 Clients.

5.1 Client to Message Broker Transfer

![Flow Diagram]

Figure 10 The process flow diagram for a Client transferring a message to a Message Broker
5.2 Message Broker to Client Transfer

Figure 11 The process flow diagram for a Client receiving a message from the Message Broker
6 Example Domain Configuration

```xml
<?xml version="1.0" encoding="UTF-8" ?>
<IPC2501DC:DomainConfiguration
    xmlns:IPC2501DC="http://webstds.gatech.edu/2501/DomainConfiguration.xsd"
    dateTime="2003-03-27T15:54:17.02-05:00"
    comments="New clients for IPC-2501 doc"
    xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
    author="Doug"
    xsi:noNamespaceSchemaLocation="http://webstds.gatech.edu/2501/DomainConfiguration.xsd"
    domainName="IPC-2501 Reference Implementation">
    <Broker brokerName="broker.fis.marc.gatech.edu">
        <PublishList>
        </PublishList>
    </Broker>
    <ClientList>
        <Client clientName="Client1.marc.gatech.edu" queueSize="200" queueFullOperation="STOP">
            <PublishList>
                <MessageSchema>http://webstds.gatech.edu/2501/GetDomainConfiguration.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/EquipmentAlarm.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/EquipmentHeartbeat.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/EquipmentError.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/EquipmentInformation.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/EquipmentWarning.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemIdentifierRead.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemTransferIn.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemTransferLane.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemTransferOut.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemTransferZone.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemWorkStart.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/ItemWorkComplete.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2541/OperatorInformation.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2546/MaterialHandlerTrouble.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2547/ProcessSessionStart.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2547/ProcessStepStatus.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2547/ItemRepair.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2547/InspectionFrame.xsd</MessageSchema>
                <MessageSchema>http://webstds.ipc.org/2547/ProcessSessionEnd.xsd</MessageSchema>
            </PublishList>
        </Client>
    </ClientList>
</IPC2501DC:DomainConfiguration>
```
<MessageSchema>http://webstds.ipc.org/2541/ItemTransferLane.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2541/ItemTransferOut.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2541/ItemTransferZone.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2541/ItemWorkStart.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2541/ItemWorkComplete.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2546/MaterialHandlerTrouble.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2547/ProcessSessionStart.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2547/ProcessStepStatus.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2547/InspectionFrame.xsd</MessageSchema>
<MessageSchema>http://webstds.ipc.org/2547/ProcessSessionEnd.xsd</MessageSchema>
</Publisher>
</SubscriptionList>
</Client>
</ClientList>
</IPC2501DC:DomainConfiguration>
7 References

HTTP – Hypertext Transport Protocol is an application-level, generic, stateless, object-oriented protocol for distributed, collaborative, hypermedia information systems. A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred. HTTP has been in use by the World-Wide Web global information initiative since 1990. For further information about HTTP 1.1, see http://www.w3.org/Protocols/rfc2616/rfc2616.html.

MIME - Multipurpose Internet Mail Extension. MIME was conceived to extend the format of Internet mail to allow non-US-ASCII textual messages, non-textual messages, multipart message bodies, and non-US-ASCII information. See RFC2045, RFC2046, RFC2047, RFC2048, RFC2049 for full specifications.


For more information about SOAP Version 1.1, see: http://www.w3.org/TR/SOAP/

For more information about SOAP with Attachments, see: http://www.w3.org/TR/2000/NOTE-SOAP-attachments-20001211.html

The SOAP 1.1 envelope schema can be found at: http://schemas.xmlsoap.org/soap/envelope/

TCP/IP – An Internet communications protocol comprised of two components. TCP is responsible for verifying the correct delivery of data from client to server, and IP is responsible for moving packet of data from node to node.

Appendix A – IPC Web-based Standards (IPC25XX)

The web-based standards (IPC 25XX) are designed to foster application integration and electronic commerce through data and information interchange standards based on XML. It assumes that application programs (including equipment interfaces) are distinct entities, and application integration takes place using a loosely coupled, message-passing approach. There is no need for a common object model, programming language, persistent storage mechanism or operating system for two applications to exchange XML messages formatted using the web-based standards. The two applications simply need to be able to format, transmit, receive and consume a standardized XML message.

The IPC web-based standards series have been identified for each of the value-added activities occurring throughout the product life cycle of an electronics product. The web-based standards are:

IPC-2500 – Framework Standard
IPC-2510 – Product Data Representation
IPC-2520 – Product Data Quality
IPC-2530 – Surface Mount Equipment Standard Recipe File Format
IPC-2540 – Shop Floor Equipment Communications
IPC-2550 – Manufacturing Execution Systems Communications
IPC-2560 – Enterprise Resource Planning Systems Communications
IPC-2570 – Supply Chain Communications
IPC-2580 – Product Manufacturing Descriptions

Table A-1 shows the correlation of the different standards in each of the series. Although not every standard has been started, the figure represents a coordinated opportunity to maintain consistency throughout the standard development cycle.
### Table A-1  CAD/CAM Standardization

<table>
<thead>
<tr>
<th>IPC Number/Function</th>
<th>-xxx1 Generic</th>
<th>-xxx2 Administ</th>
<th>-xxx3 Documnt</th>
<th>-xxx4 Board Fabricat</th>
<th>-xxx5 Bare Bd Test</th>
<th>-xxx6 Assy Manufac</th>
<th>-xxx7 Assy/ Test/ Inspr.</th>
<th>-xxx8 Comp. &amp; Material</th>
<th>-xxx9 Informa. Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPC-2500 CAMX Framework</td>
<td>IPC-2501 (Pub)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC-2520 Quality Product Data</td>
<td></td>
<td>IPC-2524 (Pub)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IPC-2530 SRFF Process Data Recipe file</td>
<td>IPC-2531 (Pub)</td>
<td></td>
<td></td>
<td></td>
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Messages are the basis of the web-based standards. Messages are the means to integrate applications at the business-process level by defining a loosely coupled, request-based communication process. Since many business processes involve one party performing a service at the request of another party, the mapping of messages to requests is natural. An XML-based messaging system with open, extensible formats captures the essential elements of an electronics business communication message while allowing flexible implementations.

It is anticipated that in the vast majority of interchanges, the exchange of XML documents and messages between trading partners or applications will occur. Implementation using the web-based standards will use a simple hyper-text transfer protocol (HTTP) transport, but business can also use other transports including file transfer protocol (FTP) and message queuing technologies. At times, a message may be short and distinct; other times the message may contain a large file or a linkage to a URI. In many instances, the data represents an action required and becomes a part of a contractual agreement between customer and supplier.

In today’s environment, many new applications are gaining native support for XML schema. These message and file transfers will require layered software that transforms native data types into XML or vice versa and converts the characteristics of the XML message into processing actions by machines, personnel, or processes.