

Boston College
Computer Science Department

Senior Thesis 2002
Michael Tierney
Middleman - Linking Data Sources & Wireless Devices
Prof. Edward Sciore

Introduction

The combined technological developments of Java and XML have helped create many advances in portability and customizable presentation of data. HTML, a cousin technology to XML, played an important role in the creation of, and shortly thereafter, the commercialization of the Internet. What HTML brought to the PC, XML will bring to cell phones, handheld computers, and PDA's. HTML allows for the formatting and presentation of text. XML takes an alternate approach to the handling of data. The markup tags in XML specify the type of data and characteristics about the data aside from presentation formatting. "HTML tells how data should look, but XML tells you what it means."¹ The markup language says nothing about the presentation of the data; rather, it says what type of data is presented.

Within the document are tags created by the developer and placed around the data describing the data type. The XML document is then parsed and processed and formatting is determined by data type. This independence from formatting is one of XML's major benefits. Because the documents do not specify explicitly how the data should appear, different presentations can be used, depending upon the user manipulating the data. For example, an animated, multicolor presentation with sound effects and voice narration would be one way of presenting data. This type of presentation would be ideal for a multimedia platform such as a powerful PC; however, a more limited cell phone browser, which lacks the capabilities for animation, sound, and even multiple colors, could not take full advantage of the data in this form. Instead, since XML supplies labels

for the data, a designer could supply a schematic for the display of the data depending upon the capabilities of the device used to view it.

Furthermore, the document can contain a multitude of tags depending on the context of the data being presented. This is because developers can create their own tags based upon the needs of the application. In standard HTML, one would describe data as being placed in a specific location, in a certain font, color, and size. In XML, data is typed and described as FIRST NAME or STREET ADDRESS or STATE, or even something totally unrelated such as COLOR. The only limits to the possible tag values are the demands of the application and the imagination of the designer. This flexibility allows XML to be a great tool for transferring commercial data from databases to end-users. The querying system can pass both queries and results in XML format; portions of the query, such as the selection criteria can be labeled as such with XML tags, and the resulting data can be similarly identified, possibly with attributes such as table and field names, as needed. XML is extensible, in that it can grow to encompass and accommodate the data needs of the developer.

While these two properties of XML seem to present great advantages to a designer of a front end for database access, what is it about this markup language in particular that shows promise in place of some proprietary language? It is simply that XML is just that, a nonproprietary system. Multiple developers all over the world (since XML supports Unicode) can write applications that parse, process, and understand XML data. There is no Apple XML, no Sun XML, and (as of yet) no Microsoft version of XML. It is all one s0.1 (i)-2 (pa5(as) r) derstandbprietand andWwoandW XanderstandIone

Prior Work

There are currently many other papers and research efforts focusing on linking

In “SQL Server for Windows CE – A Database Engine for Mobile and Embedded Platforms,” the authors, two Microsoft employees, describe a separate version of SQL tailored specifically for the capabilities of mobile devices. This version of SQL is designed to deal with the storage, battery, and bandwidth restrictions imposed by wireless technology. I see no reason that multiple platforms would require multiple versions of SQL Server.

If the base framework for SQL requests and responses were XML correspondences, then a Middleman server could be used to sit between the client initiating the query and the SQL database. The server could take the incoming XML request, transform the query into proper SQL, and then process the results returned from the database system.

The database administrator institutes filters to ensure that a client receives the correct content, but does not specify the media used to convey that content. By allowing the database to ignore the issue of media type and passing that task off to the Middleman server, both the database and the client device can enforce “the abstractions of data access that appliith at 71.2 (he) 1 (set) 0.2(i) 0.2 (id) -3 (oif) t7 (d) 0.7 (a) 0.7 (tb) -3 (of)] TJ 0 T 0.2 (s)(e)

server is ideally suited to the first type of query response, and can help ensure platform independence by converting the response of the server into an XML document. The two remaining query types provide an obstacle to the Middleman system, and the server must compensate for the continuous streams by dealing with discrete portions of the data, separating the stream into blocks of data, and converting the data pieces independently.

While this final condition limits the applicability of the Middleman system in a real-

client's personal tastes. Data could be sent to a user's system either on demand or based upon a schedule of updates. "Integrated personalization and filtering are performed at each terminal,"⁷ in the paper "Dynamic Personalization and Information Integration in Multi-Channel Data Dissemination Environments," by Goto and Kambayashi. In their paper they stipulate that, "Each passenger has a mobile terminal. There is a software agent having abilities to integrate and personalize information for the passenger in it."⁸ The reasoning behind the author's decision to handle personalization on the client side is mainly in an effort to alleviate strain on the servers during high use periods.

The Middleman server system can help to alleviate server strain, simplify the task of the client device, and personalize data as well. If the reasoning behind the author's choice to force the client device to perform the personalization is sound, then the case where processing time becomes important is during high use periods. However, wireless bandwidth, which is often a major constraint, would also be taxed during these high usage periods. Therefore, forcing the client to filter and personalize requires that extraneous and often simply unusable data be transmitted and then immediately discarded by the client. This superfluous data transmission would entail very high bandwidth costs in an environment already depleted of available signals. The Middleman system provides a compromise that allows the constraint placed upon server processing time, as well as lessens the bandwidth costs of the system proposed in Goto and Kambayashi's paper.

First, the central and local servers would not have to waste processing time on filtering and customizing the information. They can simply pass the raw data and some basic information about the client device on to a network of Middleman servers. These servers can then apply the correct filtering depending on the client device. An additional

possibility would be the storage of personalized DTD or Schema documentation on the Middleman server network that would allow for personalization of the data. After the data has been filtered and personalized, it can be forwarded on to the client device, thus reducing the amount of wireless bandwidth used. The mobile device need only append information regarding its capabilities to the original request, which is forwarded on to the Middleman system. While the adding of this supplementary information would slightly increase the bandwidth used in placing the information request, the benefits of prefiltering response data outweigh the costs imposed. The bandwidth used in sending a small text document is negligible when compared to that used when sending a color picture that the client device could not use.

Ozen's paper "Highly Personalized Information Delivery to Mobile Clients," deals with the customization of data on mobile devices. "The degree of personalization,"

“Since the queries will be executed on the documents fetched over the Internet, it is natural to expect the documents to be in XML, XML being the emerging standard for data exchange over the Internet.”¹⁰ However, with the addition of a Middleman server, the capabilities of Ozen’s system can be expanded to deal with many more formats. Middleman processes data in the natural language of the data source, be it HTML, XML, or any of a variety of database response formats, and then converts that language into XML for transmission to the client. Middleman could improve the personalization system of Ozen’s paper by sitting between the XML Repository and the data sources, or even by replacing the XML Repository and the Profile Processor altogether.

Middleman sits between the Repository and the data, intercepting data requests and responses and formatting the communications correctly. (See figure 0) Instead of requiring that all incoming data be in XML formatting, the Middleman server can handle multiple formats, yet still provide personalized data in a consistent format to the client device. Since the response to the client is sent in XML and applies a specified DTD, the client will receive a result containing only the information requested, in useable formats and media types.

power demands on the smartcard can be greatly reduced. The goal behind Kuramitsu's system is to, "Place computers everywhere in the real world environment, providing ways for them to interconnect, talk, and work together."¹¹ Kuramitsu proposes a complex system of queries and objects that is finely tailored to work with the smartcard and greatly reduces the time needed to transmit the data. However, while this object/query system is fitted to the smartcard components, it fails to generalize well to other technologies. Other devices with greater computational power could deal with the additional overhead of a more universal format, such as XML. If the data is preprocessed and pruned by the Middleman servers, then the small overhead involved in the XML

systems, such as XML, would be ideal. Furthermore, since the data is routed to multiple platforms, preprocessing and prefiltering, done by the Middleman server system, greatly reduces wasted bandwidth and allows for further personalization of the data.

By placing the Middleman between the EBS and the ED, or even by integrating Middleman function into the EBS network, the Middleman can intercept signals bound

System Design

The basic premise of my system is to use a preprocessing server to intercept requests from a user device destined for a database and to perform intermediary processing tasks on both the request and the reply. This is done by first accepting a query request formatted as an XML document. The request is structured in a specialized Middleman query. The server then parses the request document to obtain key information, such as client identification, the requested database file, the operations to be performed upon that database, and the desired result format. The Middleman server then matches the client device type, established by examining the identification against a local XML file containing a device registry. Client capabilities, such as multimedia abilities, are listed in this registry and associated with the identification tag in the XML query. This last ingredient helps provide the major benefit of this system; by obtaining specific attributes pertaining to the computing device, be it a web-enabled cell phone, an internet-ready PDA, a desktop computer, or a BlackBerry RIM email device, the Middleman server can prune down the results and tailor the information returned to the device to best match its abilities.

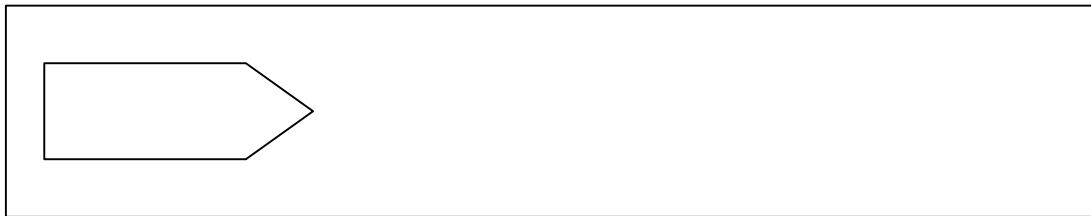
The above diagram (figure 1) shows the lifespan of a query, generated at the client device, processed by the Middleman server, and passed on to the database. The result of the query is passed back through the Middleman, additional processing is done, and the adapted result is then passed back to the client.

The Middleman server sits as a layer between the client and the database system. It waits for an incoming connection until the client sends a connection request. Upon connection, the client sends a short XML document containing a customized, simplified version of a SQL query (see figure 2) and additional information. This query is then processed, and the middleman server generates a new query, based on the language required by the target database server.

An XML based query, while quite verbose, is unambiguous and very simple to parse.

The middleman server can quickly determine which database system should be queried and what the structure of the query would be. For example, if the addressbook table

content in an alternate format. To do this, the result set from the backend database must include multiple formats in the transmission to the Middleman server. From this large set of results, the Middleman Server System creates a subset that meets the capabilities of the requesting client. Pictures become words, charts and graphs become lists and statistics, etc. Personal computers could support such graphical media, and thus if a PC instituted the query the result would include multimedia content. Other devices, however, cannot.



Finally, once the middleman server has determined that the result set from the original query contains only media displayable by the client device, the results are converted into an XML document, and that document is passed back to the client originating the query, along with any external files, such as sound files, images, or other file types.

The multitude of platforms this system attempts to accommodate requires many versions of the client program. A PC client would be quite different from a basic PDA client, but all the programs serve similar purposes and share key components. The user input must be collected together into an XML document, and a connection to the middleman server must be established. Then the device must transmit the query document, receive the results, and display the result of the query in the appropriate manner. Since the client is written in Java, the core classes can be reused in various client versions. The few classes that deal specifically with the device itself can be altered, but the essential code remains the same.

The following are two sample use cases for the Middleman Server System, detailing the tasks of the client device, the server, and the backend database.

Use Case I – Initial connection & configuration of back-end database/Middleman communication.

- 1) Using a web interface to the Middleman system, a user elects to add a database to the subscribed database listing.
- 2) Middleman responds by displaying a data entry screen, prompting the user for the database name, the field titles, and the address of the database, as well as any security restrictions necessary.
- 3) Middleman sends a test query to the database to ensure that all fields entered by the user exist in the database, and that the database as a whole exists in the

- 2) Middleman server system receives the request from the client, adds the device to a listing of subscribed clients, and assigns the client a unique identification code.

This code serves to allow the Middleman Server System a simple method of identifying the initiator of any queries. Using the identification code the system can access the database of clients and determine the device type used in initiating the query, and thus tailor the response to suit the capabilities of the client. The system responds to the initial request with an XML document containing the assigned client identification. Using the “CurrentCount” field of the registry, as

```
<Registry>
<Java_Cell_Phones>
  <CurrentCount>4</CurrentCount>
  <Subscribers>
    <Client>JavaCell1</Client1>
    <Client2>JavaCell2</Client2>
    <Client3>JavaCell3</Client3>
  </Subscribers>
  <AbilityList>
    <MIDISound>True</MIDISound>
    <WAVSound>False</WAVSound>
    <PNGraphics>True</PNGraphics>
    <BMPGraphics>False</BMPGraphics>
    <AdvancedGraphics>False</AdvancedGraphics>
```

shown in figure 4, the server would assign a designation of “JavaCell4” to the client, and update the registry file accordingly.

- 3) If the client provided a device identification code not recognized by the system, the Middleman Server System uses a default category containing a limited ability list.

- 4) The client device receives the identification code from the Middleman system and saves the code in a local configuration file. This code will be used in all future correspondences between the client device and the Middleman.

Use Case III – The client, having already initialized the device with the system, performs a query on a database through the Middleman Server System.

- 1) The client then attempts to initiate a query on the database system. A transmission is sent to the Middleman system, requesting a listing of available databases and their fields. This is done automatically when the client begins the query process.
- 2) The Middleman system receives the request from the client and responds with an XML document containing the most recent listing of subscribed databases and the fields of each database.
- 3) Upon receipt of the database listing from the server, the client parses the XML document and extracts a listing of the databases. The client program displays a menu of the available databases.
- 4) The user selects the target database from the listing provided by the client program. The client then extracts a listing of the fields belonging to the database from the XML document provided by the Middleman server. From this list the user selects fields which the Middleman server will use as a projection to query the database.
- 5) After prompting the user for the projection list, the client program displays a screen whereby the user can add selection conditions to the query. The user can

enter the conditions by selecting fields. The client then prompts the user for the type of equality (starts with, equals, less than, greater than, etc) and the value.

6) Aft

- 11) According to the device type specified in the registry, the Middleman server then prunes the response received from the backend database server. For example, if a Java cell phone originated the request, the identification specified in the original query would map to a cell phone in the registry. The Middleman server has a listing of the capabilities of each type of device, and a default low-capability setting for devices not matching any entry in the registry. Using the listing for a cell phone, the Middleman server would know to remove any non-png (Portable Network Graphic) files, any audio files, and any video files.
- 12) In the case that a conflict is found between the content presented by the database and the capabilities of the client device, Middleman elects to either remove the content, or if possible, present the information in an alternate format. Thus, it is the responsibility of the backend database to provide a low-tech representation of high-level data when possible. In this example, it would be the responsibility of the database to provide images in png format in addition to any more complex formats used, thus allowing Middleman to select from a variety of data types.
- 13) Middleman does not have any a priori knowledge of the data types of the database fields, thus maximizing the plug-and-play ability of the interface. The back-end database could change completely, and the only update needed on the Middleman side is a new listing of field names. Middleman must analyze the results as they are returned and discover the data type itself. By pushing the responsibility for determining the data type of the result set onto the Middleman server compatibility issues are reduced and the bulk of the processing load remains Middleman's responsibility.

14) The Middleman system then converts the pruned down result set into an XML document and passes it on to the originating client. Included in the XML document is a listing of the fields requested and the data type of the returned fields.

15) The client receives the XML document and parses it, extracting the results and the

Conclusion

The Middleman server system acts as an interpreting and filtering system providing customization, standardization, and optimization to a variety of client devices. The purpose of the system is to allow a multitude of platforms to access data sources without concern for formatting and media type. The Middleman can also act in concert with other systems specialized for use with mobile devices. The Middleman system provides a bridge between these specialized services and the clients. It generalizes the data and allows XML to truly be the standard in data communication.

As shown in the table in figure 5 below, the Middleman system effectively reduces the bandwidth used in response to user queries. Using a series of queries on the addressbook database requesting fields containing large data types, such as images, I

the response of the bmp and jpg files that it knew the client could not use. While the Middleman system requires a greater number of connections, due to the need to pass additional database information, the bandwidth saved in the average case was significantly lower, and contained a great deal less unusable information than direct database access.

	Number of Connections	Bandwidth Used
Direct Connection	2	420,467
Using Middleman	5	89,116

If t

Figure 5

By converting various data types into XML format, filtering the data, and eliminating extraneous media, the Middleman server links data sources and wireless devices in a seamless manner. The use of XML as opposed to a proprietary alternative assures that the data will be accessible by all, easily processed, logically arranged, and free of irrelevant formatting data. By describing the data by type information instead of formatting, XML presents a document that is easy to process, convert, and manipulate. XML and Middleman function to make data of many types and from many sources easily accessible to users at home, at work, and on the road.

Future Work

At the present time, the majority of Middleman configuration and updating is done through directly manipulating configuration files on the only implemented server. Thus, in order to add service, databases, or any other components, direct editing of the

queries can be saved in the profile on the Middleman server, and then quickly accessed via a separate menu. This listing of queries would improve the speed and simplicity of usage of the client program and would also reduce the amount of information that would have to be transferred from the client to the Middleman server to initiate the query.

Instead of a verbose XML query document, the client would only have to pass a reference to the index number of the stored query, and the Middleman could rapidly implement the query. Instead of converting an XML query into the native language query of the appropriate database server, the Middleman server would already have the converted query stored locally, and would use that cached query on the backend database.

With the extension of the Middleman Server System in these ways, the system would be a viable product in the ever-growing attempt to deliver user based personalization of content, balanced by the need to minimize bandwidth use. Middleman presents an effective tool for corporations as well as individual users, allowing employees to access essential data simply and quickly.


```

// this method takes the data stored in the rawinput vector and splits it up into fully defined field
names
// and "adjusted input" which is a vector of the actual data corresponding by index to the field
names

```

```

boolean go = true;
Stack hold = new Stack();
int count = 0;
current = 0;
while(go)
{
String temp = rawinput.get(count);
if( (temp[0] == '<') && (temp[1] == '/'))
{
if(current_ns.empty())
system.out.println("Stack error! Malformed XML or improper
stack usage resulted in popping an empty stack");
else
{
current_ns.pop();
current--;
}
}
(current_ns.push( ) -2 (tObject) ) -2 (&(temp[ ] ) -2 (&(;) TJ 0 Tc ET BT 9.96 0 0 9.96 341.48453.08 Tm /T
n
else if( (temp[0] == '<') && (temp[1] != '/'))

```

```
// processData method
    rawinput.add( (Object) (s) );
}
public String getField ( int n) {
```

```
public int loadDatabaseList() throws IOException{  
    /* xml format  
       <dblist>
```



```
this.loadDatabase(d);
```

```

                                compile.addValue(n, dpiece.getResultVal(n));
                                }
        }
    catch (EOFException eofe) {
        System.out.println(eofe);
        eofe.printStackTrace();
    }
    catch (IOException eofe) {
        System.out.println(eofe);
        eofe.printStackTrace();
    }
    return (compile);
}

```

```

private void makeQuery(String targetdb, Vector projects, Vector whereconds)
{
    // whereconds is a vector that holds an alternating series of matching (field, value) strings
    Querytype q = new Querytype;
    ByteArrayOutputStream baos = new ByteArrayOutputStream();
    DataOutputStream outputStream = new DataOutputStream(baos);
    String temp1, temp2;
    try {
        q.setTarget(targetdb);
        q.setNumFields(projects.size());
        for(int n = 0; n < projects.size(); n++)
            q.addProjList(String)(projects.elementAt(n));
        q.setNumConditions( (whereconds.size() / 2) );
        for(int n = 0 | n < whereconds.size(); n+=2 )
            {

```

```
private Stack screens = null;

public mm_control()
{
    screens = new Stack();
}
```

```
        {
            display = (Displayable) screens.pop();
        }
        else
        {
            display = new Introscreen( (Controller) this );
        }

        getDisplay().setCurrent( display);
    }
}

import java.util.*;

0 9Jsplay);
```

```

    }

    void addValue(int n, String s) {
        if(n > number_fields)
            {
                // since this is the loop control, this should NEVER happen, and if it does,
something really
                // strange is going on!
                system.out.println("Woah! somehow the number of the result being set is > total
# of fields! see class RES");
            }
        else
            results.add( (Object)(s) );
    }

    void setValue(int n, String s) {
        if(n < number_fields)
            results.setElementAt( ((String) (s)), n);
    }

}

public class Resolver

{
    private Vector _dBaseListing = null;
    private Vector _dBaseType = null;
    private int _number_bases = 0;

    public Resolver()
    {
        _dBaseListing = new Vector(5,5);
        _dBaseType = new Vector(5,5);
        _number_bases = 0;
    }

    public void setResolverDBs(Vector v1, Vector v2){
        _dBaseListing = v1;
        _dBaseType = v2;
        _number_bases = v2.size();
    }

    public int getType(String Dname){
        for(int count = 0; count < _number_bases; count++)
            if( (String)(v1.get(count)).equals(Dname))
                return v2.get(count);
        return -1;
    } // returns the language of the database indicated
}

```


Bibliography

- Chase, Nicholas, XML and Java from Scratch. Que Publishing, Indianapolis, Indiana; 2001.
- Goldfarb & Prescod, The XML Handbook Third Edition. Prentice Hall PTR, New Jersey; 2001.
- Goto and Kambayashi, “Dynamic Personalization and Information Integration in Multi-Channel Data Dissemination Environments.” Proceedings of the Second ACM International Workshop on Data Engineering fore Wireless and Mobile Access. ACM Press, NY; 2001
- Huang and Garcia-Molina, “Publish/Subscribe in a Mobile Environment.” Proceedings of the Second ACM International Workshop on Data Engineering fore Wireless and Mobile Access. ACM Press, NY; 2001
- Kuramitsu and Sakamura, “Towards Ubiquitous Database in Mobile Commerce.” Proceedings of the Second ACM International Workshop on Data Engineering fore Wireless and Mobile Access. ACM Press, NY; 2001
- McLaughlin, Brett, Java and XML. O’Reilly & Associates, California; 2000.
- Ozen, Kilic, Altinel, and Dogac, “Highly Personalized Information Delivery to Mobile Clients.” Proceedings of the Second ACM International Workshop on Data Engineering fore Wireless and Mobile Access. ACM Press, NY; 2001
- Quin, Liam, Open Source XML Database Toolkit: Resources and Techniques for Improved Development. Wiley Computer Publishing, New York; 2000.
- St. Laurent and Cerami, Building XML Applications. McGraw-Hill, NY, NY; 1999.
- Seshadri and Garret, “SQLServer for Windows CE – A Database Engine for Mobile and Embedded Platforms.” Proceedings of the 16th International Conference on Data Engineering. IEEE; 2000
- Seydim, Dunham, and Kumar, “Location Dependent Query Processing.” Proceedings of the Second ACM International Workshop on Data Engineering fore Wireless and Mobile Access. ACM Press, NY; 2001
- Villate, Pitoura, et al, “Extending the Data Services of Mobile Computers by External Data Lockers.” Proceedings of the 11th International Workshop on Database and Expert System Applications. IEEE; 2000.