

**Application for 2011 University of California Larry L. Sautter Award for  
Innovation in Information Technology**

Submission Date: May 19, 2011

Deployment Date: CBMW is fully operational as of **May 8<sup>th</sup> 2011**.

Project Name: **Consolidated Billing Middleware** Services

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## 1. Project Overview

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### 1.1 Problem Statement

Students currently cannot view or pay all their charges and make payments for tuition, housing and transportation in one consolidated way. Students currently have three website locations that they must access in order to make online payments at UCLA:

1. Billing and Accounts Receivable (BAR) payments (Tuition fees and other charges) through URSA.
2. Transportation payments (permits and services) through the UCLA Transportation website.
3. Housing payments through the UCLA Housing website.

In person, payment capabilities are also available at each of their Cashiering locations for their respective payment area where the students have to physically go to each office to make the respective payments. Students and parents have commented on the inconvenience that the lack of consolidated bill view causes difficulties in knowing when bills are due, the challenge of locating them and paying them on time and running around the different cashiering office.

### 1.2 Project Background

A new campus-wide directive is to create a consolidated student bill (**Bruin Bill**) has united several disparate service areas on campus in the identification and selection of a vendor who could provide a consolidated bill for presentation to students and a common cashiering and online payment system capable of handling PCI data and UCLA's needs. Each of these areas is physically separated on campus and has its own billing and receivables systems. Each system must interface to produce student billing data to consolidate student bill that is presented via a web portal that students currently use to view their tuition fees and make online payments.

There is also a need to consolidate many billing and payment options currently provided into one suite of online, web based, services for students. The campus also desires to replace its existing online payment gateway which serves campus department needs for online payments and the needs of other UC merchants.

**Among the functionality desired are:**

1. Bruin Bill – aka Consolidated bill for students,
2. BruinPay Plan – aka Deferred Payment Plans for students,
3. Cashiering System,
4. Online Payment System with following payment options:
  - a. Pin-less debit
  - b. Credit Card and
  - c. ACH E-check
5. Ability to provide campus merchants with shopping cart ordering and payment options,
6. Ability for campus departments to record departmental deposits – DDF,
7. Ability to accept online sign up for Direct Deposit of student refunds,
8. Capability for refunds via payment type, and Check Imaging and processing to the bank.

In the course of examining how a consolidated bill could be produced, it was determined that a robust **Consolidated Billing Middleware** is required to be built in order to standardize and rationalize the UCLA students data from different departments and deliver the same to the online Bruin Bill, Payment processing gateway and Cashiering modules in the real time mode and accept the processed payments back in to the middleware and distribute the same to respective systems in near real time mode.

## 1.3 Project Description

### 1.3.1 Goals

1. Create a repository of information in the CBMW by creating a new central datastore.
2. Consolidate the backend billing data from BAR, Housing and Transportation in that central repository.
3. Build a middleware service to retrieve and update the central repository with the consolidated billing data and the payment information for the selected vendor.
4. Build a service to retrieve and update the respective legacy systems from the central repository with the updated payment information in near real time.
5. Partner and co-ordinate with the selected vendor to build the consolidated bill presentation view by using the CB middleware service.
6. 24 / 7 availability to lookup and accept payments through CB Middleware service.

### 1.3.2 Objectives

1. The Consolidated Billing Middleware is to be a data transfer mechanism to integrate between the different systems exchanging student billing data.
2. The Consolidated Billing Middleware is to be a single integration point for the payment processor with UCLA systems besides being the single integration point for the UCLA systems themselves.
3. The Consolidated Billing Middleware is to integrate and transfer data with high reliability and performance (Technology section covers some of the software, tools and techniques used to achieve this objective).
4. The Consolidated Billing Middleware is to provide mapping of the different Department systems Accounts data (also known as **Owner Systems**) so that the different accounts appear together on the student's bill based on their configured period data ranges.

For e.g. BAR accounts are based on quarter or semester or even annual terms whereas Transportation accounts are on a yearly period cycle. The bill is requested for a registration session term, however all other accounts have to be presented as well based on the mapping.

### 1.3.3 Feature Highlights of CBMW

1. Billing Data Management in CBMW by Owner Systems
2. Billing Data Lookups from CBMW for BruinBill presentation module
3. Billing Data Posting to CBMW from Payment Processor
4. Billing Data Synchronization from CBMW to Owner Systems
5. Billing Period Mappings
6. Service extensability in CBMW
7. Policy based re-attempts for Asynchronous Message Processing and Error escalation for transactions
8. Email notification on error escalation for every failed transaction on periodic basis until successful synchronization.
9. Auto-Recovery on Message Brokers and Message processors on network glitches
10. Auto-Recovery on Cache servers with high availability clustering
11. 24 / 7 availability to lookup and accept payments
12. New Caching framework for static data and configurable auto refreshing option
13. Extended extract processing to 356 days a year on all GL, PAN and CDW

### 1.3.4 Integrated Systems with CBMW

The following systems have been integrated by CBMW.

1. Cashnet Higher One: UCLA *Student Financial Services* procured this vendor to process PCI compliant data, process payments and build BruinBill presentment.
  - a. BruinBill – Cashnet custom developed the presentment for the new BruinBill. This module uses CBMW to lookup current account information, History Bill data for 2 years and process payment through their ePay module.
  - b. ePay module – Cashnet customized their ePay module for the new BruinBill user interface. This module invokes CBMW to post student payments to UCLA after processing the payments.
  - c. Cashiering module – This module uses CBMW to lookup student data, process payments and post payments back to UCLA. Students can potentially go to any cashiering location and station across campus to pay their balances.
2. UCLA Billing and Receivables (BAR): Billing data for Registration Fees, Campus Charges, EMBA / FEMBA, Summer Sessions and more.
3. UCLA Transportation: Billing data for Vanpool Monthly. (In the next phase Parking Permits will be supported).
4. UCLA General Accounting Financial Services: General Ledger Full Accounting Unit (FAU) Validation function.

**1.3.5 Bill workflow - before Vs after Implementation**

**1.3.5.1 Students Viewing and paying their UCLA Bills online**

Bill workflow before Implementation	Bruin Bill workflow after Implementation
<ol style="list-style-type: none"> <li>1. Students decide to view and pay BAR accounts               <ol style="list-style-type: none"> <li>a. Students log on to University Records System Access (URSA) to view their online BAR accounts.</li> <li>b. Students click one account at a time to view the bill. (Regular, Summer Sessions, FMBA / EMBA, Installments)</li> <li>c. Students make their payments</li> <li>d. Students logout of URSA</li> </ol> </li> <li>2. Students decide to view and pay their Transportation account               <ol style="list-style-type: none"> <li>a. Students access Transporportation website.</li> <li>b. View their bill.</li> <li>c. Make payments for their Transportation Charges</li> <li>d. Logout of Transportation website</li> </ol> </li> <li>3. Students decide to view and pay their Housing account               <ol style="list-style-type: none"> <li>a. Students access Housing website.</li> <li>b. View their bill.</li> <li>c. Make payments for their Housing Charges</li> <li>d. Logout of Housing website.</li> </ol> </li> </ol>	<ol style="list-style-type: none"> <li>1. Students decide to view and pay all accounts.               <ol style="list-style-type: none"> <li>a. Students log on to University Records System Access (URSA) to view their online accounts.</li> <li>b. Students click Bruin Bill and view all their accounts in the consolidated view (Regular, Summer Sessions, FMBA / EMBA, Installments, Transportation, Housing)</li> <li>c. Students make their payments on all accounts or selected accounts.</li> <li>d. Student's logout of Bruin Bill.</li> </ol> </li> </ol> <p>NOTE: Housing data and the integration will be completed by Summer 2011.</p>

**1.3.5.2 Students Paying their UCLA Bills InPerson (Cashiering)**

Bill workflow before Implementation	Bruin Bill workflow after Implementation
<ol style="list-style-type: none"> <li>1. Students decide to view and pay BAR accounts               <ol style="list-style-type: none"> <li>a. Students physically visit AMCO Cashiering office.</li> <li>b. Students requests the cashier to view their balance (Regular, Summer Sessions, FMBA / EMBA, Installments)</li> <li>c. Students make their payments in the Cashiering window</li> <li>d. Students get BAR receipt and completes the payment process</li> </ol> </li> <li>2. Students decide to view and pay Transportation charges               <ol style="list-style-type: none"> <li>a. Students physically visit Transportation Cashiering office.</li> <li>b. Students request the cashier to view their Vanpool or Parking balance.</li> <li>c. Students make their payments in the Cashiering window</li> <li>d. Students get Transportation receipt and completes the payment process.</li> </ol> </li> <li>3. Students decide to view and pay Housing charges.               <ol style="list-style-type: none"> <li>a. Students physically visit Housing Cashiering office.</li> <li>b. Students requests the cashier to view their Housing balance</li> <li>c. Students make their payments in the Cashiering window</li> <li>d. Students get Housing receipt and completes the payment process</li> </ol> </li> </ol>	<ol style="list-style-type: none"> <li>1. Students decide to view and pay all accounts.               <ol style="list-style-type: none"> <li>a. Students physically walk in to any close by cashiering office.</li> <li>e. Students requests the cashier to view their balance (Regular, Summer Sessions, FMBA / EMBA, Installments, Transportation and or Housing)</li> <li>f. Students make their payments in the Cashiering window</li> <li>g. Students get one receipt and completes the payment process.</li> </ol> </li> </ol> <p>NOTE: Housing data and the integration will be completed by Summer 2011.</p>

## 2. Technology Innovation

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### 2.1 Enterprise Integration Patterns

The following Enterprise Integration patterns were applied in building the Consolidated Billing Middleware.

#### 2.1.1 Data Sharing

Billing and Accounts Receivables (BAR) system is in the same database environment as Consolidated Billing central repository and we are data sharing through triggers and asynchronous synchronization between the systems. We are using transaction management to make sure all the charges and payments that are added in to BAR systems triggers and synchronize with CB datastore as well as part of the transaction.

##### Flow of transactions from BAR to CB:

1. When a charge or a payment is added in the BAR system, the transaction triggers from the master tables.
2. Trigger invokes the stored procedure as part of the transaction.
3. Synchronize the transaction with CB.
4. Commits the transaction.

#### 2.1.2 Messaging

BAR, Transportation and Housing (**Final phase**) are synchronized asynchronously using messaging technique.

##### Flow of Payment transactions from CB to Source systems:

1. When a payment is made by a student or cashiers on behalf of student, CashNet process the payments and sends the payment transaction to CB Middleware.
2. CB Middleware persist the payment transaction, creates a JMS message to respective source system and respond to CashNet immediately with a CB transaction number.
3. One of the following CB Message Processors retrieve the respective messages and asynchronously push the payment transaction in near real time to the respective source system almost instantaneously.
  - a. BAR Message Processor
  - b. Transportation Message Processor
  - c. Housing Message Processor
4. The respective synchronizers update the students total instantaneously.



## 2.2 Architectural Considerations

The following were the architectural design considerations for Consolidated Billing Middleware

1. High throughput and low response times for Lookups from and Postings to CBMW
2. Near Real-time synchronization of postings from CBMW to Owner Systems and balance updates
3. Low Infrastructure Costs for hosting CBMW
4. Standards-based interfaces to CBMW

### 2.2.1 High throughput and low response times

This was achieved primarily by having a central database repository, a replication of the Owner Systems data. Lookup requests for Student Billing data as well as postings such as payments are retrieved from and persisted to the local DB, as opposed to invoking in real-time the Owner Systems. It's the Owner Systems' responsibility to keep their business data accurate in CBMW in real-time (or near real-time).

To further reduce response times a caching framework was developed to retrieve less frequently changing data from the cache instead of the DB on each request. The caching framework abstracts the real Cache provider implementation and process. Ehcache java client library connected to out-of-process Memory and Disk based Terracotta replicated clustered servers were chosen as the Cache Provider/s for CBMW. Different business objects can be allocated to separate caches and periodic background jobs can be configured to refresh cached data from the DB for data not getting updated through CBMW and also automated eviction policy cleans up the cache.

Similar to the lookups the postings follow the same approach to update the local DB and cache without invoking the Owner System on each request. Faster retrieval and low response times also enables CBMW to process high volume of requests in high throughput.

### 2.2.2 Near Real-time synchronization to Owner Systems

Postings from the payment processor such as payments are required to be synchronized to the Owner Systems for the book of record and reconciliation. An objective of CBMW is to synchronize these payments in near real-time besides responding quickly to the payment processor. This is achieved by invoking the Owner Systems asynchronously. A messaging broker ActiveMQ is used with Java Messaging Service (JMS) Queuing API as a notifying mechanism with small footprint messages (i.e. a message object with a Payment Transaction ID). A Message Processor process listens to the queues in the broker and is notified with the transaction id that needs to be synchronized appropriately (i.e. right protocol) to the relevant Owner Systems. Synchronization of all the payments has the updated balance returned which is persisted and available immediately for subsequent lookups.

A time multiplier based retry policy goes into effect from the broker in the event of synchronization errors. Network or Connection related errors are retried (10 Times) upto half a day. Data related errors are retried (3 times) upto a minute to give the benefit of the doubt.

### **2.2.3 Low Infrastructure Costs for hosting CBMW**

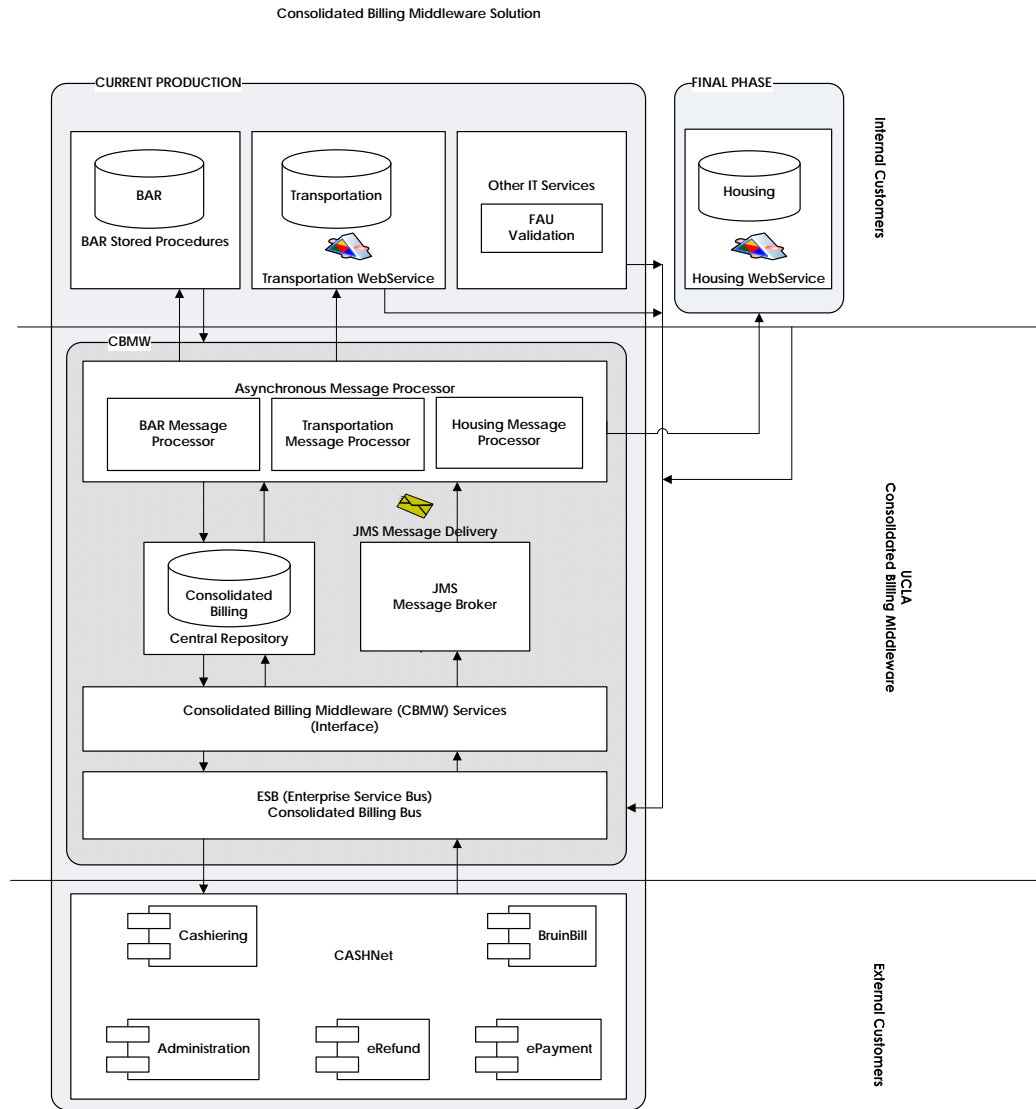
With the exception of hardware and setup costs, all technologies, libraries and applications used to develop and host CBMW are open source licensed frameworks and popular industry standards, thereby reducing the development, hosting and maintenance cost of CBMW.

### **2.2.4 Standards-based interfaces to CBMW**

Clients of CBMW use standards based SOAP 1.1 over HTTP and 2-ways SSL to communicate. WSDL standard is used for development. All of the communication or integration standards have wide industry and community support and available in various application frameworks and servers

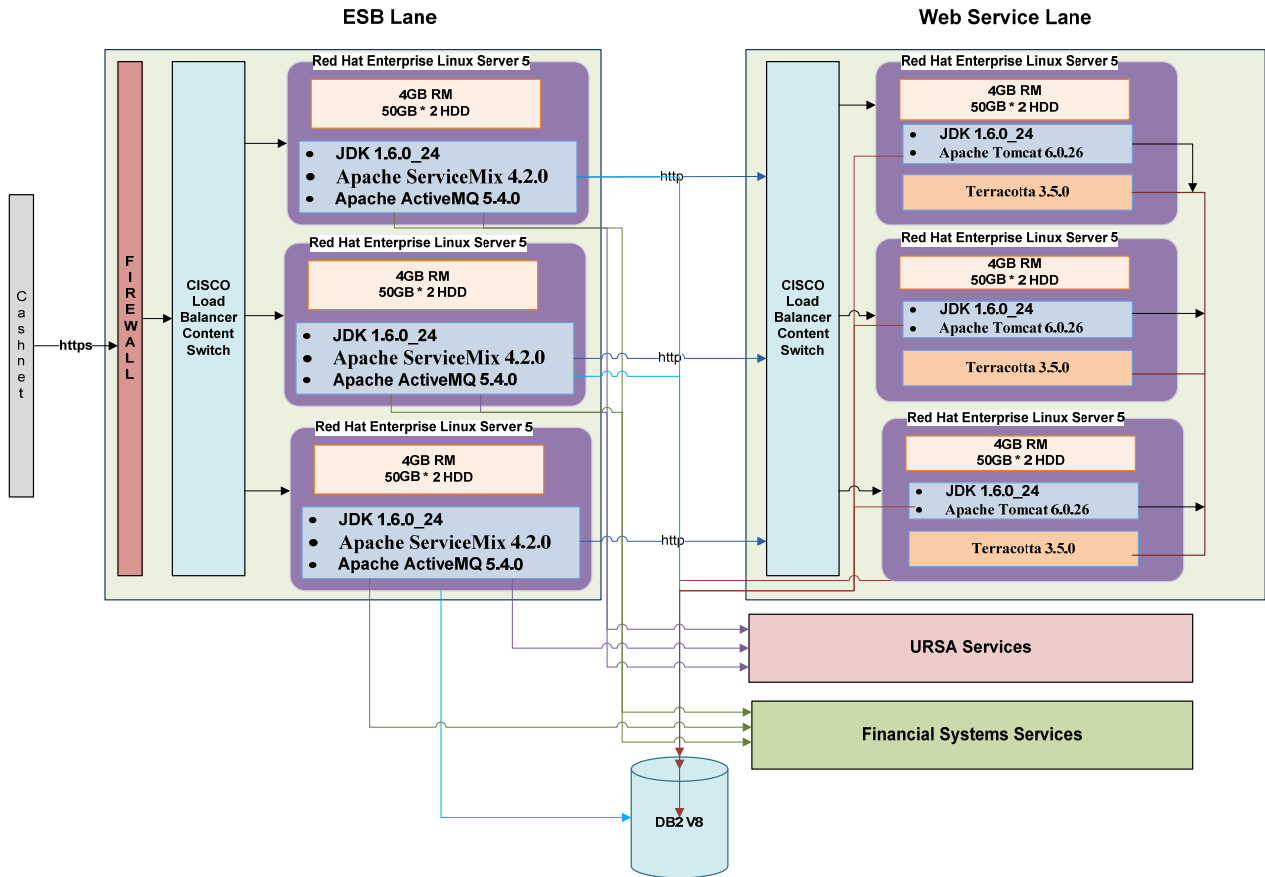
## 2.3 Consolidated Billing Middleware Architecture

### 2.3.1 CBMW Systems Integration Architecture

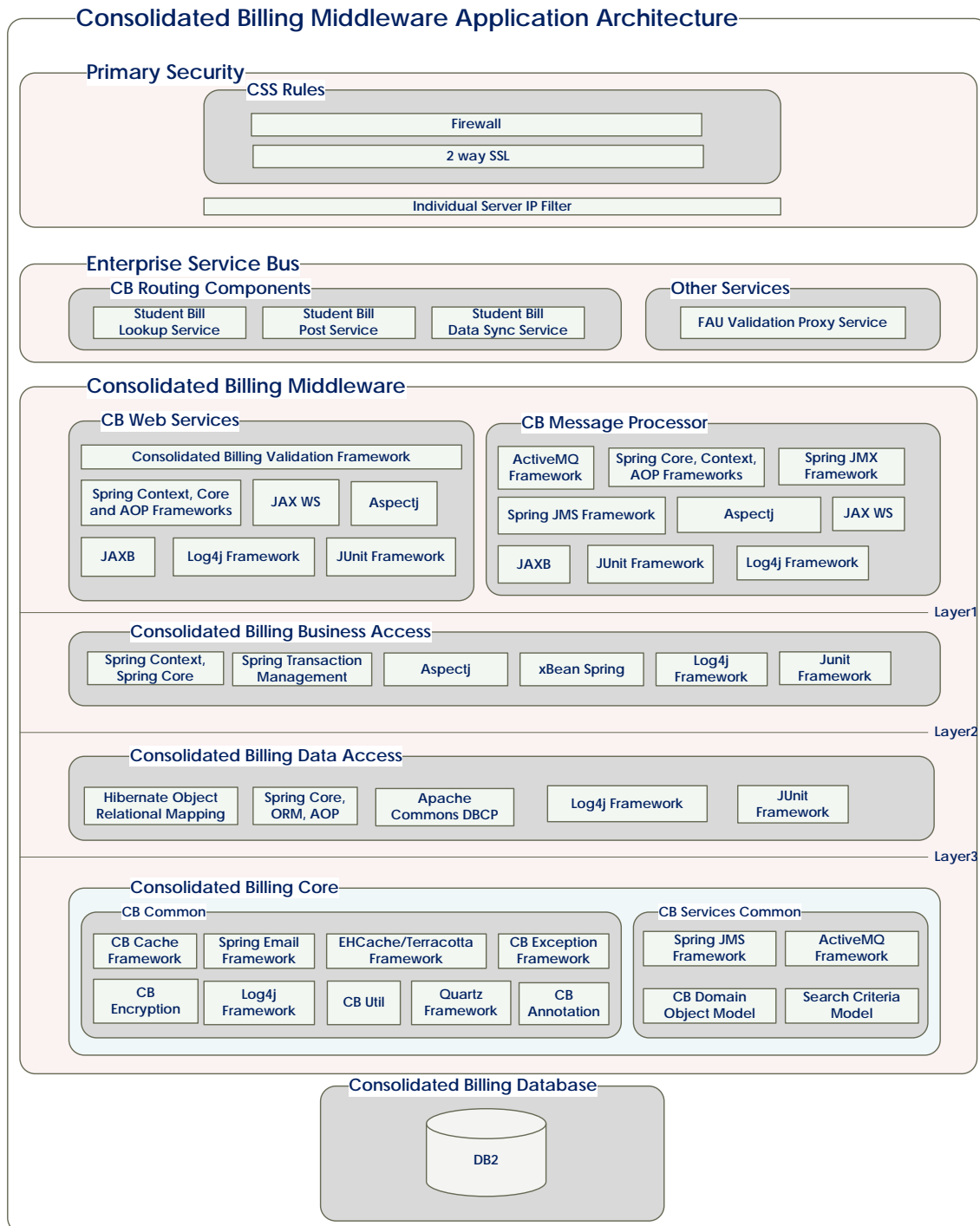


2.3.2 CBMW Server Logical Architecture

Consolidated Billing  
Logical-Production-Server-Architecture



2.3.3 CBMW Application Architecture



**2.3.4 Environment Overview**

The following is a brief description of the main technologies used in building the Consolidated Billing Middleware.

Operating System	Red Hat Enterprise Linux is an enterprise platform well-suited for a broad range of applications across the IT infrastructure.
Enterprise Service Bus	Apache ServiceMix is an enterprise-class open-source distributed Enterprise Service Bus (ESB) and service-oriented architecture (SOA) toolkit.
Application Server	Apache Tomcat is a popular open source application container.
Message Broker Server	Apache ActiveMQ is the most popular and powerful open source messaging and Integration provider.
Cache Server	Terrocotta is distributed and high available caching server.
Message Processor	CB custom developed Message processor.
Software Development Life Cycle (SDLC) tools	<ol style="list-style-type: none"> <li>1. SVN → Source code repository</li> <li>2. Eclipse → Development tool</li> <li>3. Maven → Build tool</li> <li>4. TeamCity → Continous Integration server</li> <li>5. Archiva → Code repository</li> <li>6. Junit → Testing tool</li> <li>7. Sonar → Code Review tool</li> <li>8. SOAP UI → SOAP WebServices testing tool</li> </ol>

**2.3.5 Other Teams Involved**

Teams	Names	Comment
DBA	Ramakrishnan, Jeysankar	DB design, DB implementation across environment, performance monitoring
CashNet	Grahame Clarke Satheesh Babu Vishnu Mulliappa	BruinBill UI development and Product support.
BAR	Norma Morelock Stephen Bennett Howard Lee Joe Hunt	Synchronization between BAR and Middleware
Infrastructure Services	McGillivray, Nancy Hector Tarin James (Jim) Stoker Richard Macias	Setting up the entire ESB lane, Security and all other infrastructure related tasks.
Transportation	Joshua Jackson	Cashering, CB Middleware integration

### 3. Time Line

<b>Phase 1</b>	2/24/2010	8/31/2010
UCLA Business Implementation	5/3/2010	7/23/2010
CB-Dependency Systems Development	2/24/2010	8/31/2010
<b>Phase 2</b>	6/7/2010	8/30/2010
CB-Dependency Systems Development	6/7/2010	8/30/2010
<b>Phase 3</b>	6/11/2010	5/11/2011
Design Phase	6/11/2010	11/30/2010
Development Phase	9/6/2010	3/1/2011
System Integration Testing Phase	12/16/2010	1/12/2011
Deploy Phase	12/16/2010	5/8/2011
Post Implementation Review	5/9/2011	5/11/2011

Note: Consolidated Billing Middleware is fully operational and in production as of May 8<sup>th</sup> and the final phase is to add Housing transaction data in to the Consolidated Billing Middleware.



## 4. Customer Feedback

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Here is a Customer feedback email on the Consolidated Billing Middleware:

Hi Shan,

I wanted to take a few moments to thank you directly for all the work you and your team have dedicated to the Consolidated Bill implementation at UCLA. I recognize the extra efforts extended in creating a meaningful interface to a Third Party delivered product that was not built to fully meet our needs. The middleware has helped the delivered software not only do the job the way it was designed, but has taken it above and beyond what it was able to do by the enhancements your team has provided.

I have been very impressed with the professionalism exhibited by your team, delivering every Phase on time and with a functioning interface that has worked according to specifications every time. This speaks well to the level of detail that you have demanded and received from your team.

In interfacing with students who have assisted with testing and since our go-live, they have all expressed appreciation at the additional options allowed by the Consolidated Bill, they are grateful for the ease of navigation, and the intuitive look and feel. They are excited at the additional features that will be provided in the final Phase and look forward to complete delivery of an umbrella of services to better meet their needs. Implementation of the BruinPay Plan, UCLA's first installment payment plan, has expanded their payment options and has been well received. The ability to see ALL the accounts that assess fees to students has been another great addition.

Our team is very grateful for all the work your team has dedicated to this project and recognizes that without your drive to excel, this would not be possible. Thank you very much for all your continuing efforts.

*Marsha M. Lovell*

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