4.3.2.2 EAI Platform: IBM WebSphere Message Broker

An enterprise application like E-FIS requires robust and powerful integration capabilities to enable various systems to join the ERP solution. The Advantage Business Platform includes the industry-leading IBM WebSphere Message Broker solution as the E-FIS Enterprise Service Bus (ESB). WebSphere Message Broker will seamlessly integrate the Advantage ERP with legacy Caltrans systems, as well as future best-of-breed components implemented in later IFMS phases, using a reliable, high-performance, open standards-based approach.

The Advantage ERP was built on a service-oriented architecture (SOA) using a true J2EE open standards architecture, allowing applications to connect and share data in a seamless manner. It provides native support for XML and SOAP-based messaging, and exposes common business functions in accordance with the Web Services Definition Language (WSDL) standard. Software based on a proprietary language is inherently less flexible and far more complex to integrate. Since Advantage uses standard methods, not modified industry-standard protocols, both inbound and outbound messaging will be less complex to construct and maintain when compared to ERP solutions built on proprietary language foundations.

Many of Caltrans’ legacy specialty solutions are non-SOA environments. These legacy solutions, such as CICS and other mainframe systems, must also be accommodated to build the end-to-end E-FIS business process. WebSphere Message Broker promotes a culture of interoperability, accommodating various types of integration such as file-based integration, service-based integration, and enterprise resource integration. Our EAI approach provides the flexibility for CGI to analyze Caltrans interface requirements during the implementation to determine the best integration type for each. WebSphere Message Broker enhances the flow and distribution of this information by enabling the transformation and intelligent routing of messages without the need to change either the applications that are generating the messages or the applications that are consuming them. The goal is the transparent replacement of TRAMS.

Proprietary or embedded middleware components lack the flexibility, breadth of integration and scalability that Caltrans will require. WebSphere middleware avoids the pitfalls of other proprietary EAI technologies that claim to be open and extensible, but instead lock Caltrans into proprietary vendor platforms and methods. WebSphere middleware provides interoperability and flexibility of the SOA through the adoption of open standards and data formats such as JMS, Web Services, XML, and more. This architecture makes integration with existing and future applications far less costly to build and maintain, since the applications need only communicate with the ESB following a specific format. This approach also enables Caltrans to lower the cost of managing the EAI layer since it leverages industry-standard skills (such as Java), eliminating the need to hire and train staff in proprietary skills for a specific application.
WebSphere Message Broker also has the following key capabilities that make it an integral part of CGI’s E-FIS Solution:

- Distributes any type of information across and between multiple diverse systems and applications, providing delivery of the correct information in the correct format and at the correct time.
- Reduces the number of point-to-point interconnections and simplifies application programming by removing integration logic from the applications.
- Routes information in real time based on topic and content to any endpoint using a powerful publish/subscribe messaging engine.
- Validates and transforms messages in-flight between any combination of different message formats, including Web Services, and other XML and non-XML formats.
- Routes messages based on (evaluated) business rules to match information content and business processes.
- Improves business agility by dynamically reconfiguring information distribution patterns without reprogramming end-point applications.
- Provides access control to securely deliver personalized information to the right place at the right time.

WebSphere Message Broker is comprised of two principle parts, a development environment for the creation of message flows, message sets, and other message flow application resources; and a runtime environment, which contains the components for running those message flow applications that are created in the development environment:

4.3.2.2.1 Development Environment

The development environment consists of the Message Broker Toolkit and is where the message flow applications that provide the logic to the broker are developed. The broker uses the logic in the message flow applications to process messages from business applications at run time. In the Message Broker Toolkit, you can develop both message flows and message sets for message flow applications:

- **Message Flows** – Message flows are programs that provide the logic that the broker uses to process messages from applications integrated with the CGI E-FIS Solution. Message flows are created by connecting nodes together, with each node providing some basic logic. A selection of built-in nodes is provided with WebSphere Message Broker for performing particular tasks. These tasks can be combined to perform complex manipulations and transformations of messages. For example, a message flow would transform project data received from FMIS to be processed and entered into Advantage ERP. A choice of methods is available for defining the logic in the message flows to transform data. Depending on the different types of data or the skills of the message flow application developer, the following options are available:
  - Extended Structured Query Language (ESQL)
  - Java
- eXtensible Style sheet Language for Transformations (XSLT)
- Drag-and-drop mappings
  The nodes in the message flows define the source and the target
  transports of the message, any transformations and manipulations
  based on the business data, and any interactions with other systems
  such as databases and files.
- **Message Sets** – A message set is a definition of the structure of the
  messages that are processed by the message flows in the broker. As
  mentioned previously, in order for a message flow to be able to
  manipulate or transform a message, the broker must know the structure
  of the message. The definition of a message can be used to verify
  message structure, and to assist with the construction of message flows
  and mappings in the Message Broker Toolkit. Message sets are compiled
  for deployment to a broker as a message dictionary, which provides a
  reference for the message flows to verify the structure of messages as
  they flow through the broker.

### 4.3.2.2.2 Runtime Environment

The runtime environment is the set of components that make up WebSphere
Message Broker and are required to deploy and run message flow applications.

- **Broker** – The broker is a set of application processes that host and run
  message flows. When a message arrives at the broker from a business
  application, the broker processes the message before passing it on to one
  or more other business applications. The broker routes, transforms, and
  manipulates messages according to the logic that is defined in their
  message flow applications. A broker uses WebSphere MQ as the
  transport mechanism both to communicate with the Configuration
  Manager, from which it receives configuration information, and to
  communicate with any other brokers to which it is associated. Each
  broker has a database in which it stores the information that it needs to
  process messages at run time.

- **Configuration Manager** – The Configuration Manager is the interface
  between the Message Broker Toolkit and the brokers in the broker
  domain. The Configuration Manager stores configuration details for the
  broker domain in an internal repository, providing a central store for
  resources in the broker domain. The Configuration Manager is
  responsible for deploying message flow applications to the brokers. The
  Configuration Manager also reports back on the progress of the
  deployment and on the status of the broker. When the Message Broker
  Toolkit connects to the Configuration Manager, the status of the brokers
  in the domain is derived from the configuration information stored in the
  Configuration Manager’s internal repository.

- **Broker Domain** – Brokers are grouped together in broker domains. The
  brokers in a single broker domain share a common configuration that is
  defined in the Configuration Manager. A broker domain contains one or
  more brokers and a single Configuration Manager. The components in a
  broker domain will span multiple machines, and are connected together
  with WebSphere MQ channels. A broker belongs to only one broker
  domain.
4.3.2.3 Data Warehouse/Business Intelligence Component: Business Objects Enterprise

Caltrans’ enterprise information is currently dispersed among disparate sources, limiting access to timely financial information. The ability for Caltrans management to analyze real-time information is essential to optimize the use of funds. Our proposed query and reporting solution blends key components and methodologies—including data mart/data warehouse capabilities and leading ETL tools—to simplify information collection, transformation, and aggregation. Our data warehouse/business intelligence solution is integrated with the Advantage ERP suite, providing a seamless transition between the online application and the accompanying reporting solution. The Advantage Business Platform will greatly change the reporting process, turning data into information for use by managers and users across Caltrans.

Our E-FIS data warehouse and business intelligence architecture provides:

- A dimensionally-modeled enterprise data warehouse
- A reporting toolset (powered by industry leader Business Objects) to access the data in the warehouse
- A pre-defined meta layer (“universes”) that allow Caltrans users easy access to data in the warehouse
- A series of reports designed specifically for government accounting clients that will be tailored to meet Caltrans-specific information needs

Enterprise Data Warehouse

CGI provides a comprehensive, dimensionally-modeled, out-of-the-box Data Warehouse for the Advantage ERP that will be used as the starting point for our business intelligence solution. Dimensional data models provide rapid response time for commonly-used, powerful, decision-support processing of large datasets. This Advantage data model will be enriched with information from other data sources, such as TPRC, EVRS, FIDO, and other Caltrans systems identified in the RFP, to create the enterprise data warehouse model. This data is extracted, transformed, and loaded into star schema table structures that comprise our E-FIS data model.

The distinguishing principle of a star schema is that hierarchies related to a single dimension are contained within a single dimension table to avoid the need for table joins. Each dimension table has a relationship to the fact table resulting in a star-like arrangement with the fact table as the center and each dimension table as a point of the star. In addition to the reductions of physical joins, the benefits of star schema include an easy-to-understand data model, clearly defined hierarchies, low maintenance, and very simple meta data.

The data warehouse was designed specifically for reporting purposes, and will be implemented using the Oracle RDBMS. The Advantage Business Platform also supports the creation of data marts using data in the E-FIS data warehouse. These data marts and/or OLAP cubes will store specialized data subsets from the data warehouse. The role of the data mart is to present convenient subsets of the data to Caltrans for specific functional needs. Our solution consists of all the tools required to build data marts.
CGI proposes the most advanced and complete platform for business intelligence, BusinessObjects Enterprise XI, as the E-FIS reporting and ad hoc querying solution. BusinessObjects has consistently ranked as the best-of-breed BI tool in the industry, as reported by various industry groups such as the Gartner Group. With BusinessObjects, the Advantage Business Platform will enable a broader view of business activities and provide a solid framework for financial reporting, decision making, and increased accountability.

As a CGI alliance partner product, BusinessObjects is seamlessly integrated with Advantage to provide query and reporting capability. It is accessed via single sign-on to provide online analytical processing for “slice-and-dice” capabilities, drill-through capabilities, and several electronic report distribution options. This end-to-end business intelligence solution simplifies information collection and aggregation and to integrate data across disparate systems. Combined, these technologies will establish a long-term solution Caltrans can build upon for years to provide the full view of Caltrans business operations necessary to support its vital mission for California.

BusinessObjects puts the power to create reports into the hands of individual business users. Caltrans users will be able to create their own “drag and drop” queries and reports against the data warehouse; they will no longer have to depend on IT for answer questions like “How much did it cost to complete Project SFOBB?” This frees Caltrans IT resources to focus on critical initiatives other than programming and maintaining reports.

Business Objects offers a number of features that put greater power into the hands of Caltrans end users:

- Powerful report formatting features that enable drag-and-drop placement of different text and graph elements to tailor queries and analyses result sets
- Multi-block reporting, allowing side by side display of multiple tables, graphs, and text elements on a single page, and a drag-and-drop capability to dynamically create subgroup tables from a larger query
- Support for On-Line Analytical Processing (OLAP) cubes to handle more sophisticated data analysis of complex data sets
- Row and column level security supports report bursting (distributing reports to multiple users with controlled access to subsets of report data)

BusinessObjects allows for a graphically rich information presentation to users for their analysis. Users can develop robust drill-down and drill-through functionality as well as parameterized queries and reports that can be published, shared, scheduled, or immediately run. Queries and reports can contain text as well as graphical charts (e.g., pie chart), all delivered through a Web browser, as shown in Exhibit 4-97.
4.3.2.3.1 Specific E-FIS Reporting Requirements

Throughout Appendix E, we noticed a common theme among the requirements. The themes identified were:

- Ability to perform extensive financial reporting
- Ability to send notifications
- Ability to support reconciliation
- Ability to create correspondence and perform other reporting features

The goal of the following sections is to analyze how our proposed reporting solution can satisfy each of these common themes across the E-FIS and Post-E-FIS reporting requirements.

**Financial Reporting**

Integrated with Advantage, BusinessObjects unlocks the potential of the financial system and puts its power into the hands of the people that make digital government work. The ability to perform extensive financial reporting begins with the ability to store/track data within the financial application. Therefore, we must analyze some of the inherent Advantage capabilities that facilitate reporting:

- **Chart of Accounts (COA) Codes** – Provide a means of measuring and reporting detailed expenditures and revenues. Examples include Fund Accounting elements (Fund, Object, Revenue Source, and Balance Sheet Account), Organizational Structure elements (Division, District), Budget elements (Appropriation), and other elements (Activity, Location, etc.).
  - Using this flexible COA structure, users can produce sets of financial reports in which the same dollar amounts can be classified in different ways—program managers receive reports that cut across organizational lines; legislators receive appropriations reports.
- **COA Rollups** – Assist in the reporting of accounting and budget data. They provide broad classifications of detailed data. An example rollup could be “Fiduciary” and a reporting tool can produce a list of fund accounts that operate in a Fiduciary capacity.
- **Reporting Indicators** – Facilitate reporting by increasing the ability to segment specific accounting elements within reports. Examples include Operating and Non-Operating Indicators or Major Fund vs. Component Unit Indicators.
- **Journals** – Historical record within the financial system of processed accounting data that is stored by document. Examples include the Accounting Journal or Cost Accounting Journal.
- **Ledgers** – Historical record of processed accounting data organized by one or more elements of the accounting distribution and by an established period of time. Examples include the Accounting Period Ledger or Daily Ledger.
Notifications

Caltrans identified the ability to automatically notify users as a key requirement throughout the RFP. BusinessObjects has the ability to send automatic notifications to the appropriate personal via its broadcast agent scheduler. The broadcast agent scheduler is an integrated enterprise report scheduling application that allows BusinessObjects users to schedule pre-developed or ad hoc reports in batch mode and to distribute reports to a wide range of output devices. Examples of the distribution methods include Web access as the primary method with optional implementation for PDF, Microsoft Excel, fax, e-mail, wireless, and paper (direct printer output). Known as “bursting,” this process runs the report and distributes the report to groups of users in the appropriate format based on individual BusinessObjects security settings.

BusinessObjects also provides scheduled reporting with and without input parameters. Reports can be scheduled for processing and distribution on a specific schedule (e.g., once a week), or even based on a defined condition. For those reports developed with prompts, scheduling allows the input parameters to be provided as part of the scheduling process. In addition, ad hoc queries and reports created by authorized users can also be scheduled by the authorized user. To support a paperless implementation, CGI suggests that standard reports be accessed through the report repository and allow users to access the reports when they need to pull information. This reduces the cost and effort of printing reports and distributing the reports. Users still have the capability to print reports on their own, if desired.

Reconciliation

Another common theme throughout the Caltrans RFP is the ability to reconcile data within the application and across applications. Advantage Financial is delivered with system assurance and reconciliation processes that confirm system integrity and facilitate reconciliation across multiple functional areas; examples include the Budget Versus Actuals Ledgers and Journals, System Assurance Reports, or the Check Reconciliation batch process.

Reconciliation across applications can be accomplished by Business Objects Query and Reporting capabilities upon loading of external data into the existing data warehouse and defining/modifying applicable universes. CGI will work with Caltrans to develop processes to load the data from external systems (via spreadsheets, flat files, or interfaces) into new data warehouse tables built specifically for the external data source. CGI reporting experts will work with Caltrans to define or modify universes that will properly join external data to existing data in the enterprise data warehouse. Once the universes are defined and/or modified, reports can be created to reconcile Advantage with information from external applications.

Correspondence and Other Reporting Features

As part of our proposed business intelligence solution, users can use the BusinessObjects to create letters, memos, and forms that incorporate application data with standard letter information. BusinessObjects can dynamically populate each letter with information from the data warehouse in conjunction with pre-
written “letter” text. The application also has the ability to use export text for use with word processors, such as for form letter mail merge functions.

Lastly, BusinessObjects allows for a graphically rich information presentation to users for their analysis. Users can develop robust drill-down and drill-through functionality as well as parameterized queries and reports that can be published, shared, scheduled, or immediately run. Queries and reports can contain text as well as graphical charts (e.g., pie chart) or pictures/graphics. BusinessObjects provides easy download of data to Excel, PDF, or CSV files. In addition, reports can display data in several different variations on one document or display data based on conditional formatting.

### 4.3.2.4 ETL Component: Pervasive Data Integrator

Data will be extracted from the necessary transactional systems, including Advantage ERP, via a process called Extract, Transform, and Load (ETL). After careful review of the RFP requirements and a cost/benefit analysis of several leading ETL tools, CGI proposes Pervasive Data Integrator (PDI) as the best value ETL tool for E-FIS. PDI meets all of the E-FIS requirements and is a proven, functionally sound, and fully scalable solution.

The key to an effective ETL process is to transform the data into a usable format and to correct data inaccuracies. Our solution will use the ETL functions provided by PDI to extract data from the various data sources, transform the data, and load the data into the data warehouse. Additional systems, including the TPRC, EVRS, and FIDO reporting systems will populate the data warehouse efficiently through the PDI tool, but PDI is much more than a data warehouse-building tool in the Advantage Business Platform. The conversion team uses pre-built conversion maps to upload legacy data and activity into the Advantage ERP. The integration team uses PDI to convert data between different formats or for real-time data integration from multiple applications and operational data stores, including data integration as a Web service.

PDI provides developers easy-to-learn and simple-to-use graphical tools to quickly define and economically maintain automated ETL jobs. To lessen the impact of the new ETL tool to Caltrans developers, CGI technical staff, trainers, and change leaders will work closely with the identified Caltrans developers to effectively transfer knowledge for a smooth transition.

Data will be extracted from the necessary transactional systems, including Advantage ERP, via a process called ETL. The key to an effective ETL process is to transform the data into a usable format and to correct data inaccuracies. Our solution will use the ETL functions provided by Pervasive Data Integrator to extract data from the various data sources, transform the data, and load the data into the data warehouse.

### 4.3.2.5 Relational Database Management System: Oracle

Our platform for business success uses Oracle’s 10g Relational Database Management System (RDBMS) software. The RDBMS will be used for managing the various data sources in our solution, such as the Advantage transactional database and the data warehouse.
4.3.3 Technical and Application Architecture

Caltrans is making a significant investment with E-FIS and the larger IFMS initiative to improve financial visibility and support better decision making. A large number of legacy systems will be migrated to E-FIS, but this will not include all systems required to run the business. Many of the legacy solutions will continue to operate, and future systems will be developed to address new business requirements. In both cases, the ability to share data seamlessly with E-FIS is an absolute must.

Seamless and cost effective integration with legacy systems, regardless of technology, is a unique attribute of our solution and one to which we want to draw attention. As we describe in this section, the Advantage Business Platform uses a completely open architecture that leverages well-established technology standards to expose critical business services and support data sharing. We have no proprietary software to get in the way, or to constrain future extensions. With our Service-Oriented Architecture (SOA), E-FIS can communicate with virtually any other system with little regard for the legacy technology or software platform. Caltrans will have the utmost flexibility and freedom, with the lowest possible total cost of ownership.

Saugatuck Technology’s spring 2007 white paper, “Reducing TCO: Keys to Selecting Government ERP Solutions,” positioned TCO as a key, if not the key, deciding factor in ERP acquisition. Their research, which follows, identified the top five TCO factors that should be included in governmental ERP solution evaluation and selection:

1. Industry-Standard Technology and Skills at Application Architecture and Interface Layers

Almost any ERP solution can be considered “standardized” since they have developed technologies that are used throughout their solutions. But solutions built (“architected”) on industry-wide, non-vendor-specific standardized technologies such as Java/J2EE and XML can deliver significantly reduced TCO, and reduce the likelihood of being “locked in” to a single vendor’s technologies and services for the life of the ERP solution.

Widely supported technologies enjoy larger and more available skills bases, as well as a broader array of third-party add-ons, applications, and technologies. More choice based on industry standards tends to enable lower costs through market competition.

2. Customization

Solutions requiring the least amount of customization tend to deliver lower TCO. In Saugatuck’s experience, ERP solutions developed for specific markets deliver lower TCO for enterprises within those markets. Solutions that are built from the ground up for market-specific business processes, operations, requirements, reporting, compliance, and other important factors, are less likely to require extensive customization. They are more likely to require skills that are familiar to, and available within, those markets.

Government is a prime example of a set of markets with very specialized business requirements. Commercial applications and modules can be
customized to meet these requirements, but this will add significantly to the solution TCO.

3. Scalability

ERP solutions are usually architected for growth and designed to scale. But growth and scalability within government are rarely a matter of simply increased processing power or additional users. ERP solutions should be able to scale in the same way that the government organization scales: from internal growth, to changes in responsibilities and constituencies, to changes in relationships with (and responsibilities to) outside entities.

4. Management/Governance

The modular nature of some ERP solutions makes it difficult to effectively and efficiently manage these solutions across the enterprise. Different modules can have different reporting capabilities and functions, use different data types, or other technology/usability factors may come into play. This may be a result of different modules or features being developed using different software development tools or languages, or from different capabilities acquired by the ERP vendor over time. These factors add to the complexity and cost of the ERP solution.

5. Acquisition

All ERP suites and functionalities are not the same, and budgets are not unlimited—ERP solutions, like anything else, must be affordable. Acquisition cost is an important factor in TCO, but should not be the sole cost consideration.

Saugatuck’s research supports the importance CGI places on government-specific focus and low TCO. Our solution incorporates government-specific business processes, requirements, reporting, and compliance to reduce customization requirements.

4.3.3.1 E-FIS Architecture

The CGI E-FIS Solution consists of proven, industrial-strength COTS products integrated within an SOA framework that is both nimble and adaptable. As business requirements evolve, so will E-FIS, adding new components and data sources as required without the burden of costly retrofits or complex integrations. Exhibit 4-111 provides a comprehensive view of this architecture, showing each of the major components and technologies proposed for E-FIS.

Advantage ERP is the core COTS component that will perform the primary financial management functions. IBM WebSphere Message Broker provides the horsepower for the Enterprise Service Bus, and will handle messaging and service orchestration between the various components. Paired with Advantage are best-of-breed COTS products to provide infrastructure services such as reporting and business intelligence, Extract-Transformation-Load (ETL), and a Data Warehouse.
There are many different approaches for implementing a multi-tiered architecture. We have selected a non-proprietary implementation for E-FIS based on the J2EE open standards platform. This decision provides the following benefits:

- A solid and proven foundation for modern enterprise computing
- Lower TCO by increasing the pool of resources and support options through common terminology
- A standards-based implementation that fully supports a decoupled interface with legacy systems, and removes the constraints often imposed by inconsistent software platforms and technologies

The following subsections provide additional details regarding the E-FIS architecture and key components.
4.3.3.1.1 Advantage ERP Architecture

Advantage employs a multi-tiered (also known as “n-tiered”) architecture that separates presentation, business logic, data, and other functionality such as integration services, into logically distinct components. This configuration, shown in Exhibit 4-112, provides architectural flexibility from many perspectives including scalability to meet future growth needs, selection of different platforms to meet potential changes to technology standards and directions, and insurance against technology obsolescence.

Exhibit 4-112: Advantage N-Tier Application Architecture

N-tiered architectures provide several benefits including:

- **Increased Flexibility** – Ability to swap out or upgrade components within a layer without undue effort
- **Increased Scalability** – Components in each tier may be replicated to increase capacity
- **Increased Security** – Allows implementation of a “layered defense” and “reduction of attack surfaces”

The Advantage architecture implements a Model-View-Controller (MVC) architecture pattern where presentation, business logic, and persistence are decoupled. An MVC separates design concerns (data persistence and behavior, presentation, and control), decreasing code duplication, centralizing control, and making the application more easily modifiable. Within the Advantage architecture, the controller is comprised of the Advantage Servlet; the view is comprised of the Page Objects and HTML pages in the Presentation Logic Server; and the model is comprised of the Data Objects and Query Objects in the Business Logic Server.

All Advantage tiers are supported on top of a TCP/IP network and related IP protocols. HTTPS is the primary protocol, which simplifies the network implementation, such as firewall setup, since it is non-proprietary and familiar to network and security administrators. It is used to communicate between the Web browser and the Web server and between the Web server and the application server.
In the subsections that follow, each tier of the Advantage ERP is described in terms of functions, software components, and communications between each.

**Client Tier**

Advantage implements a thin HTML client for maximum flexibility and no client software distribution. This architecture also minimizes the impact to the network relative to other client-centric models. Our thin client is only responsible for rendering HTML and JavaScript, both Web browser standards. The client is only responsible for transmitting user requests and displaying the results of a user request (i.e., service request model). This provides the following specific benefits:

- **Zero client administration**—no need to rollout new software versions to each client
- **Low network bandwidth requirements**
- **Secure access through the latest Internet security measures such as HTTPS with 128-bit encryption**
- **Web browser interface that provides a portable access mechanism across devices**

Using HTML clients provides support for a broad range of users, and the Advantage HTML client in particular, does not rely on proprietary plug-ins that can substantially limit performance and decrease application reliability. Rather, the HTML client leverages HTML 4.0 and higher, Cascading Style Sheets (CSS), and JavaScript that are supported by the most popular Web browsers, such as Microsoft Internet Explorer 6.0/7.0 and Netscape 7.2. In addition to PCs, many other devices support these technologies, which will make it easier for Caltrans to broaden access to E-FIS in the future.

Additionally, a Web browser client is the de facto industry standard for thin client implementations. Web browsers support traditional end users, as well as external users (such as vendors through Vendor Self-Service), and administrators (such as for security administration, workflow administration, and job administration). Advantage contains built-in accessibility features meant to support the federal government’s Section 508 requirements as well as the W3C Web Content Accessibility Guidelines (WCAG) 1.0. The system has been certified for use with JAWS® for Windows used in conjunction with Microsoft Internet Explorer.

**Presentation/Web Tier**

The Advantage presentation tier is responsible for presentation services including navigation, session management, transaction request management, and page navigation. The Advantage presentation tier is implemented as a thin layer using a Web server and application server. On receipt of a request, the Web server acts as a broker and passes the HTTPS request to the appropriate transaction handler within the business application server components. The business logic server is responsible for processing requests. The results of the completed service request are then passed back through the presentation logic server for presentation processing and then back through the Web server to the client Web browser for rendering, serving HTML pages through HTTPS.
By employing a Web server tier as the broker for user interaction, any compliant HTML client device can be used, creating additional future flexibility for Caltrans. The CGI E-FIS Solution will employ multiple Web servers to support horizontal scalability for load-balancing and fail-over services connected through a load-balancing switch. Advantage supports a number of different compliant Web servers. We have proposed the IBM HTTP Server as the Web server for the CGI E-FIS Solution.

Advantage does not process any business logic at the Web tier. Instead, Advantage supports presentation processing in the J2EE application server. Advantage logically processes user requests by passing them to the Advantage Servlet that in turn interacts through two major logical components: the presentation logic server and the business logic server.

The Advantage Servlet accepts communications originating from the end user’s Web browser and communicated via the Web server. The Advantage Servlet is responsible for interacting with the Presentation Logic Server to satisfy user requests. As such, it acts as the “traffic cop” of the application—mediating between the Web components and the EJB components.

The Presentation Logic Server, also contained within the Presentation/Web Tier, issues requests for data to the Business Logic Server either to be provided by the Data Objects or the Query Objects. The Business Logic Server returns an optimized result set that is used by the Page Objects for constructing the HTML view to be rendered on the end users Web browser. Any updates made to the data are sent by the Presentation Logic Server as updates to the business components and these updates are managed by the Business Logic Server using the appropriate concurrency control (Advantage supports optimistic and pessimistic locking that can be configured for each individual business object).

**Application/Business Logic Tier**

The application server tier maintains the business logic and core application processes of the Advantage solution. Advantage adheres to a true n-tiered architecture and enforces the business rules at the application server tier. Advantage does not employ the legacy client-server technique of database-specific stored procedures for business rules support. Such an implementation would not allow for the benefits of a modern n-tiered architecture, such as database independence.

The business logic tier is responsible for processing requests, and is at the core of the Advantage application. The processing of a request generally requires access to persistent data stored in a database. This is accomplished through standard JDBC calls to the RDBMS in the data tier. The results of the completed service request are passed back through the presentation logic server for presentation processing and then back through the Web server to the client Web browser for rendering.

The Advantage application server tier contains multiple logical software servers that perform various services such as business rules processing and transaction processing. For reliable transaction processing, the Advantage architecture is integrated with a DTS-standard application server product—IBM’s WebSphere Application Server. WebSphere provides the processing environment using the industry standard J2EE specification. Advantage uses the J2EE specification to
support an open, non-proprietary architecture. Some J2EE standards used by the Advantage solution include Enterprise Java Beans (EJB), JavaMail (SMTP, POP3 support), eXtensible Markup Language (XML) for transaction data formatting, and Java Database Connectivity (JDBC). Our non-proprietary approach will provide a better harmonization between Advantage best practices and Caltrans' current and future technology standards.

The business logic server executes within the Enterprise Java Beans (EJB) container and provides a high-performance execution environment for managing the business objects that encapsulate Advantage functionality. The Business Context EJB controls business object processing and is implemented as a stateless session bean. The business objects in turn contain the implementation of the business logic and are implemented in the following two types:

- **Data Objects** – Data objects map to entities physically persisted to the Advantage data repository in the data tier. A data object contains the set of attributes (both persistent and derived virtual attributes) to which business rules are attached.

- **Query Objects** – Query objects represent “views” of joined or restricted data objects. A query object provides an abstracted, reusable view of one or more data objects that protect client components from changes to the underlying data objects. Query objects can also have “virtual” attributes calculated at runtime.

Additionally, the Advantage framework provides common services that enable processing within the Application Tier, such as:

- **Workgroup Services** – Advantage includes a rich workflow engine that supports dynamic, multi-dimensional workflow rules and roles, enabling departments to construct checklist processes and process flows with or without dependencies. This allows multiple, coordinated, simultaneous routings of in-process activities for the parties involved in an event. The workflow engine will route documents through the pre-defined workflow business rules and facilitate the review and approval of documents as they progress through their lifecycle.

- **Security Services** – Advantage Common Security Framework (CSF) is a broad Java security framework that provides security services to Advantage. The Advantage CSF architecture is built around the core Java security API that includes Java Cryptography Architecture (JCA), Java Cryptography Extension (JCE), Java Authentication and Authorization Service (JAAS), and Java Secure Socket Extension (JSSE). Advantage CSF consists of a set of layered security services that provide an integrated set of security functions to Advantage.

### Database Tier

The database server tier performs the data storage functions and is implemented using industry-leading relational database management systems (RDBMS). The Advantage application components access the RDBMS using JDBC, and support a wide range of reporting options. Within this tier, we strictly process standard SQL requests. No business logic (e.g., in the form of embedded stored procedures) is executed within this tier, in compliance with current Web application best practices for portability and platform independence.
Another key design principle for the Advantage architecture is decoupling the business logic from any concern for the data’s physical persistence mechanism. Hence, the business objects use a connector architecture whereby they interact with the Advantage data repository using the eXtensible Data Architecture (XDA) component. The Advantage XDA supports multiple persistent stores; For the CGI E-FIS Solution we will use Oracle as the persistent store and the business objects are configured to use Oracle. The XDA will use the database connection and transaction pooling services provided by the J2EE container (i.e., WebSphere Application Server). The connector supports two-phase commit using the Java Transaction API (JTA) ability. The XDA architecture provides a high degree of convenience and flexibility. The XDA for accessing data in an Oracle RDBMS uses JDBC APIs for interacting with the database. Database connections use a generic account for connecting to the database and these connections are pooled to improve performance and scalability.

Integration Services Tier

The Advantage architecture provides numerous mechanisms for integrating with other systems both internal and external to Caltrans. Data can be received or sent through standard communication channels and protocols, such as file transfer, Web services, and messaging. This includes support for everything from direct data access integration services and traditional legacy batch interfaces to modern services-oriented integration using web services. We will work with Caltrans during the implementation phase to select the proper integration method for each legacy solution, considering data volumes, formats, frequency, and performance requirements.

4.3.3.1.2 Infrastructure Services

The CGI E-FIS Solution consists of the following infrastructure services that perform specific business functions, and must interact with E-FIS functional components:

- **E-mail** – The e-mail infrastructure service will enable the CGI E-FIS Solution to send and receive e-mail. The service implementation will interface with the DTS SMTP enterprise gateway and use SMTP as the protocol for all outbound e-mail.

- **Fax** – The fax infrastructure service will enable the CGI E-FIS Solution to send and receive faxes. The service implementation will leverage the fax server infrastructure that is proposed as part of our solution. DTS will host the fax server infrastructure, including the hardware and software.

- **EDI** – The EDI infrastructure service will enable the CGI E-FIS Solution to use the Xebec Value Added Network (VAN) to send and receive files. The service implementation will interface with the Xebec EDI software to process electronic invoices.

- **Electronic Payments** – Processing of electronic payments received and posted by Caltrans will be done by this infrastructure service that acts as a common electronic payment gateway. The service implementation will leverage existing Caltrans contracts with vendors (such as Official Payment Corporation) for processing electronic payments, such as credit cards and EFT.
- **Forms Management** – Generation of output forms will be accomplished using Adobe Central Pro for generating output forms.

- **ETL** – Even though it is not depicted as an infrastructure service in Exhibit 4-111, ETL capabilities will be available as a broad service within the CGI E-FIS Solution. The service implementation will expose Pervasive Data Integrator ETL capabilities as a set of Web services that can be accessed by other consumer applications.

4.3.3.1.3 **Business Intelligence/Data Warehouse**

A primary goal of E-FIS is to make the right information available at the right time to support business decisions. Not all of this information will reside in one data store. Therefore, a data warehouse combined with a robust business intelligence tool are required to consolidate critical information, and make that information available through reports and data mining.

CGI’s E-FIS Solution supports an integrated and robust enterprise Business Intelligence (BI) solution based on the industry-leading Business Objects Enterprise XI for query and reporting. Business Objects supports WebSphere Application Server for its execution environment. Unlike other business intelligence products that cannot support WebSphere Application Server, use of WebSphere Application Server for Business Objects creates a single middleware platform for Caltrans across the entire E-FIS Solution, increasing resource utilization, and decreasing total cost of ownership.

In Business Objects Enterprise XI, there are five tiers: the client tier, the application tier, the intelligence tier, the processing tier, and the data tier. To provide flexibility, reliability, and scalability the components that make up each of these tiers will be installed on multiple servers (various other deployment models are also supported by Business Objects Enterprise XI, including deployment of all components on a single machine). Exhibit 4-114 illustrates how each of the components fits within the multi-tier system.

- **Client Tier** – The client tier is the only part of the Business Objects Enterprise XI system that the end users directly interact with. This tier is comprised of applications that enable the users to administer, publish, and view reports and other objects. Business Objects InfoView is a web-based interface that allows end users to view, schedule, and keep track of published reports. Each Business Objects Enterprise XI request that a user makes is forwarded to the Business Objects Enterprise XI application tier.

Exhibit 4-114: Business Objects Enterprise XI Application Architecture
In the context of the California Department of Transportation, the proposal outlines the following tiers:

- **Application Tier** – The application tier hosts the server-side components that process requests from the client tier as well as the components that communicate these requests to the appropriate server in the intelligence tier. The Web server receives requests from the client tier and forwards these directly to a WebSphere Application Server where the Web Component Adapter processes the request. The application tier includes support for report viewing and logic to understand and direct web requests to the appropriate Business Objects Enterprise XI server in the intelligence tier.

- **Intelligence Tier** – The intelligence tier manages the Business Objects Enterprise XI system. It maintains all of the security information, sends requests to the appropriate servers, manages audit information, and stores report instances.

- **Processing Tier** – The processing tier accesses the data and generates the reports. It is the only tier that interacts directly with the databases that contain the report data.

- **Data Tier** – The data tier consists of an operational data store (i.e., the Caltrans Advantage data repository) and the E-FIS Data Warehouse. Business Objects will access either data source through the processing Tier.

### 4.3.3.2 Approach to Customizing the Advantage ERP

On occasion, there may be specific customer requirements that may not be accommodated through the extensive system configuration options. In these situations, the CGI E-FIS Solution includes a robust visual design and development environment. The advanced application configuration process takes place within the visual application development environment (ADE) of the Advantage Design Studio, which is designed for rapid design, development, deployment, and custom configuration of Advantage application components. In most cases, advanced configuration does not require formal programming for customization of business rules. Our Advantage visual ADE automates the construction of complex application business logic through “code by exception” paradigm. Developers customize business rules through a point-and-click, declarative rules approach—eliminating the need for in-depth coding knowledge of a traditional programming language or a proprietary language. Exhibit 4-115 provides some sample panels from our visual ADE.
4.3.4 Approach to System Interfaces

The E-FIS solution will bring together a large number of software applications and systems to meet Caltrans’ daily business needs—some applications are within Caltrans (such as CAS and IMMS) and others are applications supported by other agencies and departments (such as SCO). Collectively these applications form the “Caltrans enterprise” and must work in a coordinated and seamless manner. To support the business processes that cross multiple applications within Caltrans, we need Enterprise Application Integration (EAI).

CGI has extensive experience in the development of stable, sustainable interfaces and will apply these best practices, methodologies and approaches in developing the over 75 interfaces identified in the E-FIS RFP. In this regard, CGI considered the following criteria in deciding the integration architecture for E-FIS to support the various system interfaces:

- **Application Coupling** – Our approach was to minimize dependencies between the applications being integrated so that each can evolve without having an impact on other applications and systems at Caltrans. Hence, loose-coupling was a key focus in the proposed integration architecture.

- **Intrusiveness** – CGI wanted to keep changes to applications being integrated to a minimum (avoid if possible) and keep the amount of integration code required to a minimum.

- **Technology** – CGI wanted to interface with a wide variety of platforms, application architectures, programming languages and communication protocols, to meet the needs of existing systems and applications at Caltrans, as specified in the RFP.

- **Data Format** – Our approach was to establish a common data format for use by all integrating applications or provide a centralized approach to translate between message formats without the various applications having to perform this translation.

- **Data Timeliness** – Caltrans is looking for a reliable environment wherein data exchanges happen in real-time. CGI wanted an integration approach that supported high-throughput real-time exchange of data.

- **Data or Functionality** – CGI wanted an architecture that supported the integration of application data and functionality across the various systems and applications.

- **Remote Communication** – The E-FIS RFP was clear that the integration had to support a heterogeneous and distributed application ecosystem. Therefore, to support remote communication efficiently, CGI wanted the capability to perform asynchronous communication along with synchronous communication.

- **Reliability** – The integration architecture had to be reliable in terms of guaranteed delivery of messages and ability to handle errors and failures.

It is clear that all of the above integration criteria cannot be addressed by a single integration approach. Therefore, CGI has adopted a holistic and broad approach to integration within the CGI E-FIS Solution.

The integration architecture for CGI’s E-FIS Solution needs to interface with a wide variety of platforms, application architectures, programming languages and
communication protocols. Caltrans’ integration needs to include inter- and intra-agency/department cooperation and coordination. Further, the integration architecture will need to evolve over time to accommodate changes in Caltrans’ application and technology infrastructure. Caltrans will come to depend on this integration for core business processing; therefore, CGI has incorporated reliability, scalability, and security into the Advantage Business Platform’s integration architecture.

The proposed CGI E-FIS Solution is organized in multiple layers as described earlier in this document. The Enterprise Integration layer cuts across the various architectural layers within our solution and represents the diverse integration capabilities of our solution. As shown in Exhibit 4-121, there are five distinct types of integration capabilities within our E-FIS Solution. These integration types are described to demonstrate the capability of our architecture.

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**Exhibit 4-121: CGI E-FIS Solution – Enterprise Integration Capabilities**

Caltrans has identified the E-FIS system interfaces in the RFP. During project implementation, CGI in conjunction with the Caltrans architecture team will evaluate each of the E-FIS system interfaces and determine the most applicable integration type to use based on the business and technical requirements for the system interface. Further, the protocols listed in the figure are only a representative set and not an exhaustive list of all possible protocols for the given integration type. The types of integration are:

1. **Content Integration** – Provides the capability to distribute application-specific content using various delivery mechanisms, such as e-mail or the Web. The term “content” in this context refers to information that is being produced by the CGI E-FIS Solution. For example, Web pages for the Advantage ERP are integrated with BusinessObjects Enterprise XI for consumption by Caltrans users via a Web browser. Similarly, report
output can either be viewed online, distributed using e-mail (as an attachment) or saved to disk.

Another example where we will use content integration is in the replacement of the existing interface between the American Express Billing System and ResX—a Caltrans third party vendor travel system—from where an e-mail is received on a monthly basis that contains an Excel spreadsheet.

2. **Process Integration** – Integration at the process layer allows the CGI E-FIS Solution to integrate with external process and workflow engines.

3. **Service Integration** – The CGI E-FIS Solution sits on a service-oriented architecture (SOA). Hence, it provides the capability to respond to service requests (as a service provider) or to initiate service requests (as a service consumer). The Advantage Business Platform also consists of an Enterprise Service Bus (ESB)—WebSphere Message Broker—that is responsible for the routing and delivery of such service requests across systems and applications at Caltrans.

   For example, in the case of integration with the Xebec EDI VAN for utility payments on a weekly basis, the Advantage ERP will generate a utility payment request that will be routed by WebSphere Message Broker to the EDI common infrastructure service. This approach decouples the Advantage ERP from the EDI engine and creates a reusable service that would be available to other Caltrans applications and systems.

4. **Component Integration** – Provides the capability to integrate components across applications by exposing an API. This type of integration is typically considered a lower level of integration and creates a more tightly coupled interface compared to other integration types, such as Service Integration. However, this type of tight coupling may be necessary and desirable depending on the situation and integration requirements. The communication protocols are specific to the type of component being integrated (for example, EJB integration using RMI/IIOP).

5. **Resource Integration** – This integration type provides data integration and integration with legacy applications using file transfer, magnetic media, and database sharing. We anticipate that many of the interfaces identified by Caltrans will leverage this integration option, since most sub-systems will exchange data with Advantage in the same format that they exchange data with TRAMS. Examples include METS using database sharing, SCO using magnetic media for file transfer, and FMIS using FTP file transfer. The type of integration provides the “lowest common denominator” for integrating with the CGI E-FIS Solution. A couple of common integration scenarios leveraging this type of integration are:
   - Batch transactions delivered as a flat file to be processed as business transactions by the application server within our solution.
   - A data feed from one or more external systems processed by an extract-transform-load (ETL) tool that is to be loaded into the CGI E-FIS Solution data warehouse.
The type of integration to use will be determined after an analysis of the integration requirements. Further, under certain scenarios, the proposed integration may leverage more than one of the integration types described above. For example, arrival of a batch transaction feed (or ETL data feed) from an external source may trigger an event using the Service Integration approach such that the CGI E-FIS Solution is notified and the appropriate steps are initiated for executing the Resource Integration.

We understand that the specific interfaces will be prioritized and selected as part of the requirements validation effort. Further, existing interfaces will be reviewed by CGI and Caltrans to determine the best approach to addressing these interfaces within the CGI E-FIS Solution. Exhibit 4-122 lists the categorizations supported by the CGI E-FIS Solution and will be considered when reviewing the 75 interfaces identified in Table 5 and Table 6 of the RFP. The categorization will help in determining the integration approach to use from the ones described above.

### Exhibit 4-122: Categorization of System Interfaces

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Classifications based on Data Exchange Synchronicity</strong></td>
<td></td>
</tr>
<tr>
<td>Online Interface</td>
<td>The CGI E-FIS Solution is exposed through Application Programming Interface (API). The CGI E-FIS Solution will provide the capability for external systems to retrieve data from its repositories through the usage of programmatic interfaces.</td>
</tr>
<tr>
<td>Batch Interface</td>
<td>The CGI E-FIS Solution will receive or provide the data, based on the data flow direction of the interface, in a predetermined format for consumption by external agency system. The data will be sent at specified interval such as every day, week, month, or year.</td>
</tr>
</tbody>
</table>

| **Classifications based on Data Exchange Protocol** | |
| FTP/SFTP | The CGI E-FIS Solution interface is exposed through FTP; data to be exchanged is packaged in a file based on an agreed format. |
| Services | The CGI E-FIS Solution exposes services that are designed to allow applications to both locate and communicate with its services based on XML-based web services standards such as SOAP and using transport protocols such as HTTP and messaging. |
| Database | The CGI E-FIS Solution provides data transfer between different databases. Specifically, this kind of interface is used to move data between Advantage data repository and the data warehouse or the data warehouse and the data marts. |
| RMII/IIOP/Host Calls | The CGI E-FIS Solution provides direct integration of the external system using native protocols supported by the components, such as RMII/IIOP for Advantage ERP. These are synchronous interfaces between two systems requiring immediate exchange of information. |

| **Classifications based on Data Flow Direction** | |
| Outgoing Interface | Outgoing interfaces are the interfaces where CGI E-FIS Solution business processes initiate the information exchange with external systems. These outgoing interfaces may or may not have incoming responses being returned by the external system depending on whether these interfaces are to read external data or provide certain data update to the external system. |
Incoming Interface

Incoming interfaces are the data exchange initiated by certain events taking place in external applications, or queries being initiated from external systems. The CGI E-FIS Solution will need to initiate certain business processes based on these external events or provide appropriate data responses back to these systems.

Classifications based on Message Exchange Patterns

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Request-Response</td>
<td>In this type of message exchange, the service requester sends a request that is processed by the service provider that then sends a reply (or response) back to the service requester. This is a synchronous interaction since the service requester waits for the response (the underlying transport used for this interaction can be synchronous, such as HTTP; or asynchronous, such as messaging).</td>
</tr>
<tr>
<td>Request-Callback</td>
<td>In this type of message exchange, the service requester sends a request with a correlation identifier and callback address. The service provider will process the request asynchronously and invoke the callback handler with the response and correlation identifier upon completion of the service. The callback handler will process the response.</td>
</tr>
<tr>
<td>Publish-Subscribe</td>
<td>In this type of message exchange, the publisher will publish an event (business event or system event) to the ESB. The ESB will notify the systems that are subscribed to receive the specific event being published.</td>
</tr>
</tbody>
</table>

In developing our approach to system interfaces, we recognize that Caltrans currently has existing interface and data sharing capabilities with external systems and systems within Caltrans. As part of the E-FIS project, Caltrans wishes to either expand, refine or re-implement these interfaces. We believe that our integration approach to interfacing with the various systems enables Caltrans to support the existing system interface approaches, such as file transfer or database sharing, while establishing a forward-looking integration architecture based on SOA to meet its current and future needs. This approach meets the challenges faced by Caltrans today, namely:

- **Change** – The CGI integration approach conforms to CEAP guidelines and exposes the capabilities of the applications as services. The application invoking the service does not need to know the implementation nor does it rely on a specific implementation of the service. Similarly, the application providing the service is free to make changes to the implementation of a service without any impact on the applications that request the service. This capability is immediately realized in the interface between Advantage ERP and Construction Automation System (CAS). The CAS system capabilities will be exposed as a set of services. The initial implementation of those services will be provided by the existing CAS system. Later, the implementation will be switched to using the integrated Construction Management System (CMS)—this change in the implementation will be transparent to E-FIS, since the service interface will remain the same during this period of transition.

- **Complexity** – The CGI integration approach eliminates the disparate point-to-point interfaces that exist within Caltrans and establishes an
open standards-based integration solution to meet future needs. Additionally, the CGI integration approach meets the requirements in the RFP, namely:

- Capability to integrate with heterogeneous provider application architectures using standards-based binding mechanisms, such as messaging, XML/HTTP, SOAP/HTTP,
- Ability to absorb changing functional and technical requirements through loose coupling between the integration points, and separation of the service interface from the service provider implementation,
- Ability to reuse common infrastructure services within Caltrans,
- Consistency, security, and integrity across disparate systems by storing information in one place with the ability to share data using E-FIS services, and
- Vendor and platform neutrality.

Fragmentation – Caltrans currently has a number of stand-alone tools to support business processes. The proposed integration approach will integrate these tools by encapsulating them within a set of services and providing a single interface to the consumer application.

### 4.3.4.1 Enterprise Service Bus (ESB)

CGI is proposing an integration approach using the ESB. In an ESB architecture, systems and applications interact via messages, which enter and exit service implementations through endpoints. This approach is capable of connecting numerous application endpoints. ESBs combine messaging, Web services, XML, data transformation, and management to reliably connect and coordinate application interactions. It eliminates the need for custom construction of each point of integration. The systems and applications need no awareness of the underlying communication protocols or physical location; they see simple in-boxes and out-boxes. Because of this mapping, services can be upgraded, moved, or replaced without disrupting existing business systems or modifying applications. Exhibit 4-123 illustrates the components that make up an ESB.

![Exhibit 4-123: High-Level View of an Enterprise Service Bus](image)

The ESB provides several options for handling existing systems and applications, an important capability given the number of the external systems that are currently exchanging information using batch-oriented flat-file processes.
Based on our understanding of the Caltrans applications, we are proposing an integration approach that supports the following three interaction profiles:

- **File Drop Service Interaction Profile** – Files are deposited into a specified location as defined in the service interface using the appropriate protocol, such as FTP. A listener will detect the file and initiate the appropriate action to process the file and route it to the consumer of the file. This approach provides Caltrans with a significant benefit, allowing a batch interface to appear to CGI’s E-FIS Solution as a message based real-time interface.

- **Web Services Service Interaction Profile** – Services are provided using Web Services as an end-point. Web Services will conform to the WS-I Basic Profile for interoperability.

- **Message Service Interaction Profile** – Interaction with WebSphere Message Broker will be conducted using JMS or MQ API.

This service-oriented integration approach leverages many well-known architectural patterns. The main architectural decision is to decouple the different components within our solution by adopting an asynchronous communication pattern. To this end, we adopted the Messaging pattern where the communication is carried out by Messages exchanged over WebSphere Message Broker. Other key patterns we will use if the specific situation warrants includes the Mediator pattern and the Composite pattern. With the Mediator pattern, messages are routed, removing any service interdependency. The Composite pattern enables the creation of composite services that reuse atomic services through orchestration. The other key architectural pattern is to Route messages, an instance of the Mediator pattern that removes service interdependencies. Furthermore, the architecture supports plugability thereby decoupling the specification and implementation of service functionalities. The service-oriented interface allows the services to interact with the rest of the system, while hiding their internal structure. Finally, the Composite pattern enables the creation of composite services that reuse existing services within the solution. These architectural and design patterns make the CGI E-FIS Solution architecture extremely flexible and extensible thereby being able to support the system interface needs of Caltrans.