City and County of San Francisco's SF*go* Program: An Innovative and Integrated Video and Data System for Transportation Management Centers

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ABSTRACT

The City and County of San Francisco's SF*go* Program is nearing completion of the design of a new State of the Art Transportation Management Center. As part of this process, a robust video and data system had to be designed that would meet the needs of the Department of Parking and Traffic operators, as well as linking in with the ITS field devices to be implemented as part of the overall Program's Initial Phase.

This paper presents the video and data system that will be constructed as part of the Initial Phase, including the specific components within the control room and equipment room of the Transportation Management Center (TMC). Since the system will consist of an all-digital, all-Internet Protocol (IP) network operating over Ethernet, including digitized and encoded video, there are several options to consider when bringing the information to the TMC and sharing it with other City departments and regional and state partners. In addition, the system had to be flexible to accommodate changes to configurations during future phases, with a special emphasis on web-based applications for information sharing.

In addition, because of the use of different system elements that will be provided by different manufacturers, the system integration process will be critical to the proper installation of the system. The paper describes in detail the different components within the TMC, how each component relates to the other components, and provides guidelines for the actual implementation of the video and data system through a high level Concept of Operations.

INTRODUCTION

The SF*go* Program will install various ITS field devices and construct a new Transportation Management Center (TMC) for the Department of Parking and Traffic (DPT). Within the TMC, there will be several large screen displays for operators to view information provided by the field devices and other sources. In order to provide and integrated environment within the TMC with all of the different components, the system must be designed for a high degree of functionality and flexibility.

This paper presents a summary of the different elements of the video and data system, and the different options evaluated for the SF*go* Program in order to provide an integrated environment for the different components.

SYSTEM COMPONENTS

The specific components that are included in the TMC Video and Data System are the following:

- Large screen displays (up to four screens with an 84" diagonal)
- Central software communications server
- Central software database server
- Video server
- Application server
- Workstation clients
- Graphical display controller

Each of these components is described in the following sections.

Central Software Communications Server

This server will be responsible for communications with the traffic controllers and other field devices including variable message signs (VMS) and detection stations. The information requested from a workstation client will be processed through this server to the specific field devices. It will be this server that will perform functions including data uploads and downloads and data acquisition for real-time monitoring. It will be linked with the Database Server where the field device databases will be stored.

Central Software Database Server

This server will be linked with the communications server and with the client workstations. It serves as a keeper of database information for the different field devices (e.g., traffic signal controllers) from which the workstation clients can retrieve information. Also, any updates to the database elements from the communications server will be stored in this server.

Video Server

This server is responsible for the decoding of all digital video streams from the field including in the control information from the moveable CCTV cameras. The video and control data streams will already be encoded and compressed in the field using field encoders. When a user requests a video image, the video server will request that video image based on the IP address of the field encoder. If the camera is a moveable camera, the encoder will also encode the control data for the camera. The video server will have the appropriate drivers to enable the user to control the camera through the video server. In addition, this server will be responsible for publishing video streams to other authorized users who request a specific video feed. This includes pushing video feeds to a graphical display controller for display of the large screens within the TMC. The graphical display controller is described later in this report.

Application Server

The purpose of this server is to provide the interface between the other servers, the workstation clients within the TMC, and other clients from within the DPT and other agencies. For the SF*go* Program, the application server will interface with the database and communication server for data from the field devices including the traffic controllers, variable message signs and detection stations. It will also interface with the video server to provide video images and control data when requested by a client workstation. Lastly, it will interface with the graphics display controller for placing information on the large screen displays.

Workstation clients

The workstation clients are the personal computers located at each operator console and on each SF*go* staff person's desktop. The workstation client will act as the interface between the end user and the application servers. If multiple clients request the same information (e.g., video image), the application server will be responsible for providing the same information to the clients. In addition, the workstation clients will be used to place images on the large screens and modify how those images appear on the large screens. Through an interface with the application servers, the clients will be able to retrieve information from the database and video servers. The information can then be placed on the large screen displays through an interface with the graphics display controller.

Graphical display controller

This device will serve as the interface between the application server, the video server and the large screen displays. The purpose of this display controller is to enable the user to place any combination of images and information on the large screens and be able to manipulate the images in a dynamic way. This includes placing dynamic maps, video images, and other sources on the same screens, where the separate screens all act as a single screen.

Figure 1 illustrates the elements of the Video and Data System within the TMC.

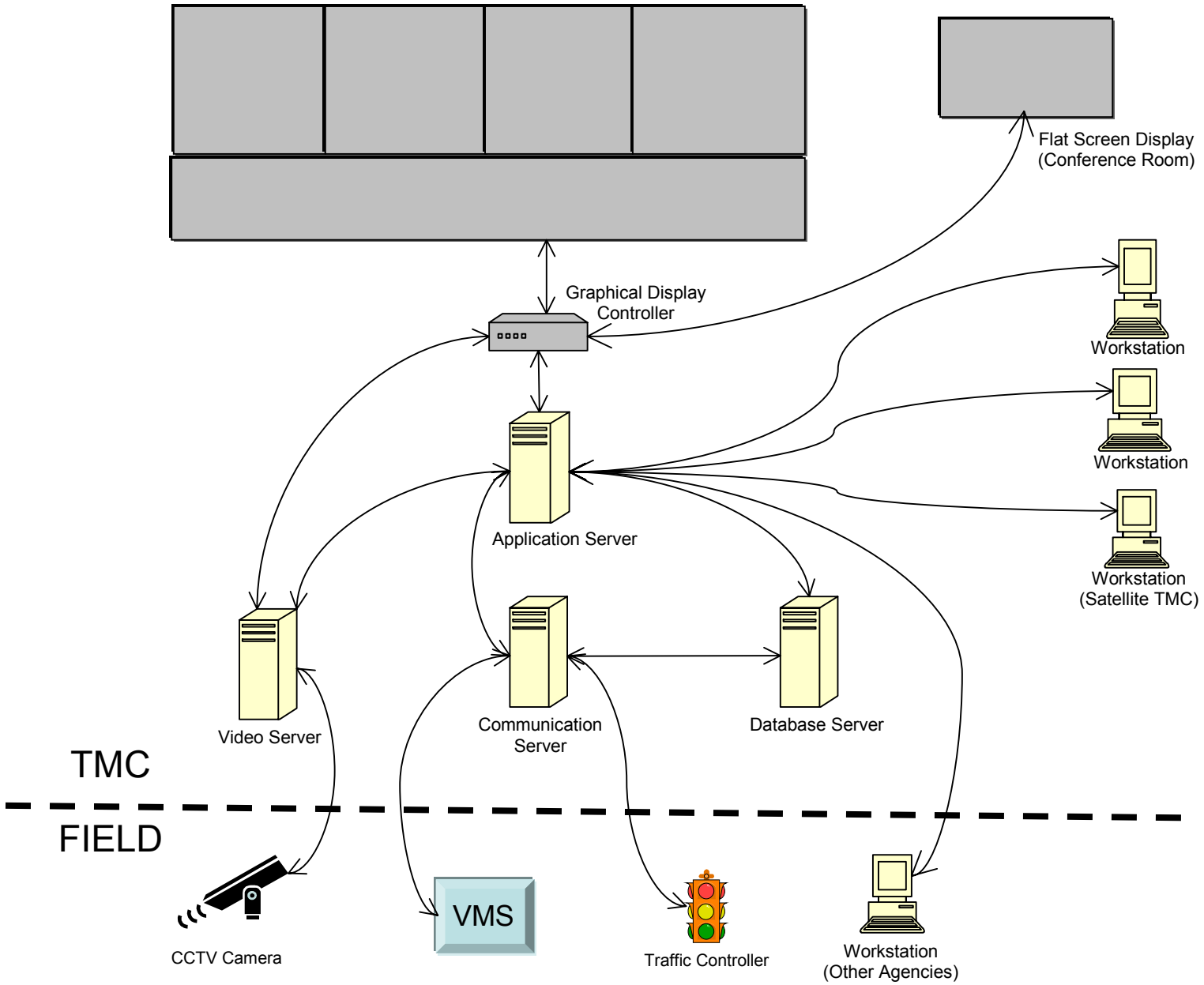

Figure 1
Video and Data System Elements

USER INTERFACE

In terms of user interfaces, several options were considered. These included the following:

- Have separate user interfaces for all applications;
- Integrate the Video and Data applications into one user interface and maintain a separate user interface for the large screen displays; and
- Have a single, integrated user interface for the three applications.

Under the first option, there would be separate user interfaces for the Data System, the Video System and the Display Screen System. This would require the user to open up separate windows fir each application. As an example, with separate user interfaces, if a user wants to view a video image when a map display is on the screen, a separate application window will need to be opened in order to request the video. Moreover, if the user wanted to display the images on the large screen display, a third user interface would have to be opened to gather the images through the application server and then have it projected on to large screen display through the graphics display controller. While this option requires the least amount of integration, it is not recommended since it will be too cumbersome for the users and operators to perform their functions in an efficient manner.

For the second option, two user interfaces would be developed, one for the video and data and the other for the graphics display. This would require the user to open a separate user interface whenever any piece of information is to be projected onto the large screens. While this option requires some integration, it also limits the user's flexibility for retrieving and displaying important information. It is therefore not recommended.

For the last option, there would be a single user interface developed for the entire video and data system within the TMC. This user interface will enable an operator to request video from CCTV cameras and data from any field device and display it on their workstation client and place it on the large screen displays. It is also envisioned that the operator will have the ability to configure and manipulate the large screen displays differently from their own workstation displays. Although this option requires the most integration of different applications, it provides the maximum flexibility for the users and operators. Subsequently, the third option was recommended.

CONCEPT OF OPERATIONS

This section describes the Concept of Operations of the Video and Data System for the TMC. It provides a summary of the functional relationships between each of the elements. Refer to Figure 2 for the following discussion of the elements within the TMC.

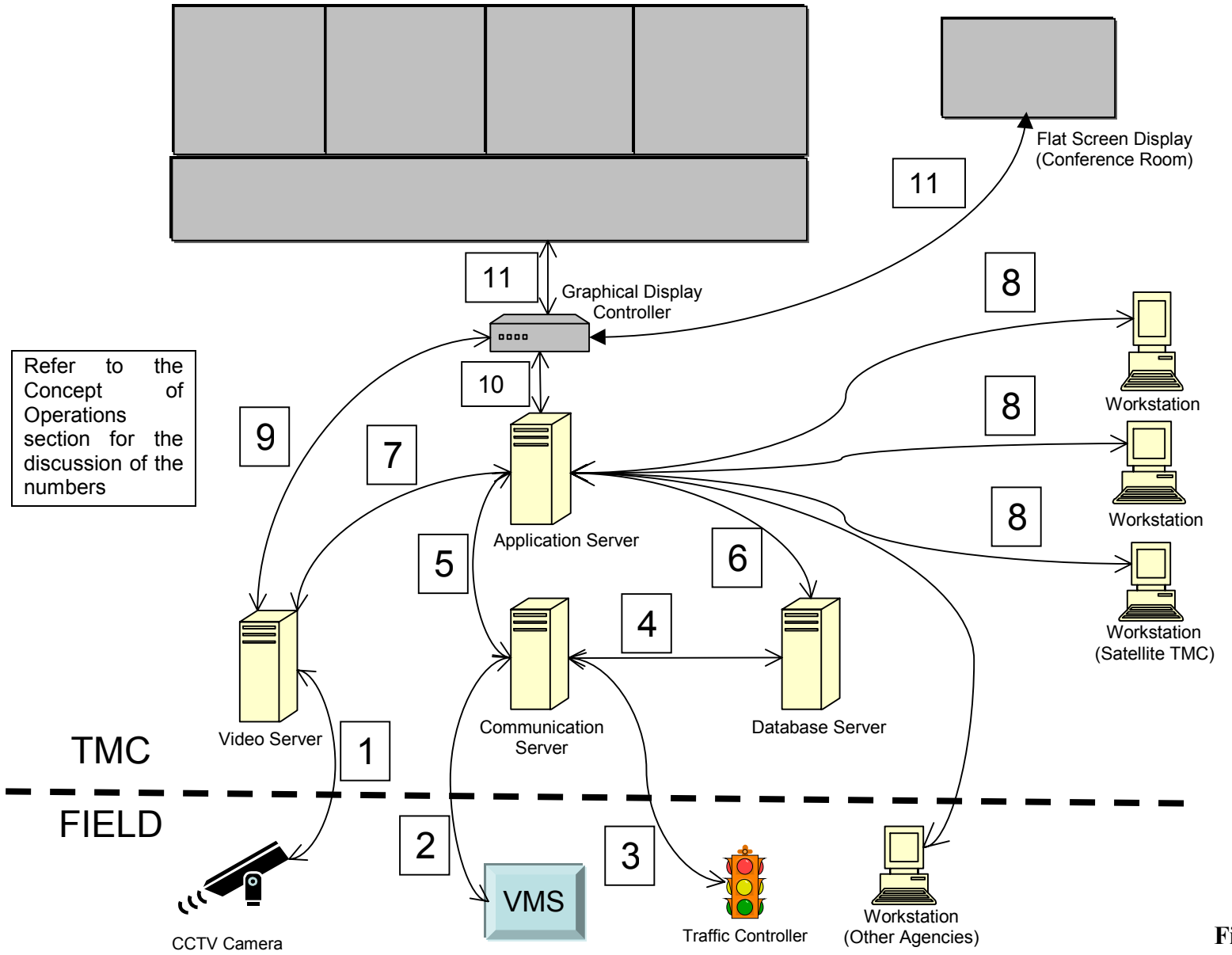

Figure 2
Concept of Operations

The following describes the relationship of each of the components of the Video and Data System. Refer to Figure 2 for the number reference.

1. CCTV Camera – Video Server link: The analog video feeds from the CCTV cameras in the field are encoded into digital format (MPEG4 or MJPEG) using a field-hardened encoder. The encoded video information and control data (to move the camera) are then converted into Ethernet frames. The field encoder also gives each frame a specific IP address (one IP address is given per encoder). The video server requests the encoded video and control data information based on the IP address and decodes it at the TMC.

2. Variable Message Sign – Communication Server link: The variable message signs will communicate with the central software communications server using serial-to-Ethernet interfaces. The serial data that the signs currently use will be converted to Ethernet frames. The interface will also give each frame a specific IP address (one IP address per interface). The communications server requests and sends information to and from the sign based on the IP address.

3. Traffic Controller – Communication Server link: The traffic signal controllers will communicate with the central software communications server using the Ethernet port (10Base-T) that is located on the 1B card of the controller. Each controller will be given an IP address. The communications server will send and receive information from the traffic controllers based on the IP address of each traffic controller.

4. Communication Server – Database Server link: The communications server will be connected to the database server for exchanging and storing database information for the field devices. It will be linked with the Database Server where the field device databases will be stored. When there are any updates to the database elements from the communications server, the new information will be stored in the database server. The database server will be a keeper of database information for the different field devices from which the clients can retrieve information.

5. Communication Server – Application Server link: The application server will link with the communication server to gather information requested by workstation clients. This could include display maps of traffic controllers and message signs, real-time monitoring of traffic signals, and communication status with field devices.

6. Database Server – Application Server link: Similar to the link between the communication server and the application server, the database server will provide database information to the application server as requested by workstation clients. This could include the entire database of a traffic controller, the message set for a

particular variable message sign, or the traffic count database for a detection station.

7. Video Server – Application Server link: This is the link between the video and application servers which provides video information as requested by workstation clients. When an operator requests to see a video image from a workstation, the workstation requests the video image with the application server, and then the application server will request the video image from the video server. Any control information from a workstation client will also be processed through this link. In addition, the request for video images from other departments within DPT and agencies outside of DPT would be via this link.

8. Application Server – Workstation Client link: This link provides the interface between the workstation clients and the video and data servers for the SF*go* network. All video and data applications requested by a workstation client will be processed through this link including display maps of the traffic signals, video image and VMS display information. In addition, any requests for information from ITS field devices by other agencies and other DPT departments would be processed through this link.

9. Video Server – Graphical Display Controller link: This serves as the link where encoded video streams from the video server are sent to the display controller for decoding and placement on the large screen displays.

10. Application Server – Graphical Display Controller link: This link serves as the link where data streams from the field devices, except the CCTV cameras are processed for the display controller to place on the large screen displays.

11. Graphical Display Controller – Large Screen Display link: This is where the display controller is connected to the screen displays through a bank of video cards in the display controller. The video cards enable the display controller to process images on multiple projection units to act as a single screen.

SUMMARY

The primary requirement for the SF*go* System is to provide the maximum flexibility for the staff and operators, especially with the display of information on the large screens. It is highly desired to minimize the number of different user interfaces to the different applications.

Based on this requirement, the following are recommended for the configuration of the video and data system within the Transportation Management Center:

- Utilize separate servers for the video and data elements of the network.
- The video server would be responsible for the CCTV camera elements.

- The data server(s) would be responsible for all other ITS field devices.
- The video and data servers would be connected via an application server.
- The large screen display will be controlled via a single graphical display controller.
- A single user interface between the application server and the display controller should be provided for ease of use by staff and the operators. This will require integration efforts between the vendors for the video server, central system software, and the graphical display controller.
- The application server user interfaces and software "hooks" should be developed by the central system software system integrator.

By having an integrated environment within the TMC, the Video and Data System will provide the necessary tools for the SF*go* Staff to properly perform their functions.