HONOLULU'S TRAFFIC CAMERA SYSTEM -The Medium is the Message

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Abstract

The Traffic Control Center (TCC) in the Department of Transportation Services of the City and County of Honolulu, Hawaii is responsible for traffic operations, including the deployment of Intelligent Transportation System technologies, on the local highway network of the island of Oahu. It is also responsible for the operation and maintenance of traffic signal control system on both local and state facilities. Honolulu has approximately 750 traffic signals and 600,000 registered vehicles. About 350 signals are connected to the TCC via fiber-optic cable. The addition of 20 CCTV traffic surveillance cameras in March 2000 brought the total to 88 cameras covering Oahu's urban portion of the arterial and freeway network. In late 1996, the College of Engineering at the University of Hawaii was linked to the TCC in order to facilitate a joint research and development program between the City and the University. One element of this program was the staged development of an internet-based traveler information system initially offering "near-real-time" snapshots of traffic conditions and later expanding to "real-time" streaming video functionality.

This paper presents a brief description of the TCC and explains how Honolulu has developed, through effective partnerships, technology, software, and integration its traveler information web site – Honolulu Traffic Camera System, including the variety of viewing options available to the web user. Special emphasis is placed on the capturing, digitizing, and serving both the "snapshot" and the streaming video feeds. The communications protocols and procedures between the University and the TCC are also explained, as are public response, innovative use of the web content, and non-traffic related uses of the service.

Introduction

The City and County of Honolulu constitute a single local jurisdiction encompassing the entire island of Oahu, Hawaii. The island has a resident population of about 870,000 and *de facto* population, which includes visitors present but excludes residents that are temporarily absent, of about 1 million. There are about 600,000 registered vehicles and approximately 1,500 miles of paved roadways on the island.

Figure 1 shows the extent of Oahu's freeway system. It consists of the Moanalua Freeway (M.F.), Interstate Highways H-1, H-2, and the latest addition, H-3, which was fully opened in December 1997 between the Pearl Harbor Naval Station at one end and the Kaneohe Marine Corps Air Station at the other. Parethetically, although Hawaii is not part of the contiguous states, a portion of the Interstate system is located in Hawaii

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primarily because of the "defense" aspect of the National System of Interstate and Defense Highways.

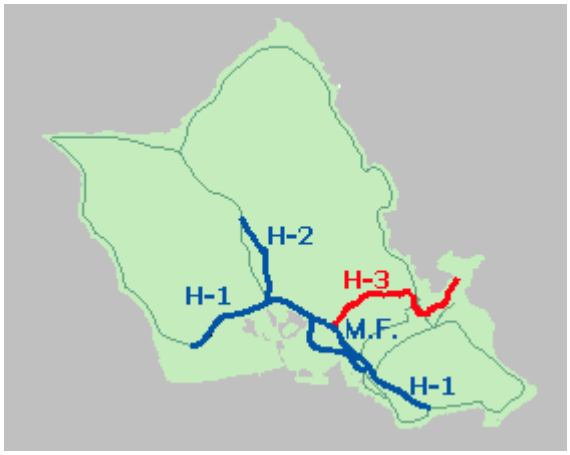

Figure 1: Oahu's Freeway Network

H-1, Oahu's oldest and most heavily used freeway facility, runs along the spine of Honolulu's most dense Primary Urban Corridor and carries an average daily vehicle volume of over 200,000 at its busiest section. This 10-lane section is listed among the most heavily used in the nation [1].

As a result of historical circumstances, major responsibility for traffic surveillance and control on the state and local network rests with Honolulu's Department of Transportation Services (DTS) through its Traffic Management Center, generally known as the Traffic Control Center (TCC) or *Trafficenter* for short. An exception to this rule is the H-3 Freeway that is equipped with a separate management center. The H-3 center is operated by the Hawaii Department of Transportation (HDOT) and monitors the environmental conditions (e.g., pollutant concentrations) inside a modern one-mile tunnel in addition to vehicular traffic.

The Traffic Control Center (TCC)

In 1986, the Department of Transportation Services (DTS) identified the need and recognized the benefits to be derived from a centralized Traffic Control Center (TCC). The TCC would serve as the main operational and control point for the island's 750 traffic signals. During the construction of the Center, the traffic signal controllers were replaced with the CALTRANS Model 170s and were set up to run on a BI Trans QuickNet traffic management and control software system. The signals employ loop detection. Within Honolulu’s central business district, interconnect lines were installed to network the first 350 traffic signals back to central control and the TCC began operations in 1988.

Recognizing early that video cameras would provide the real-time and accurate information necessary for efficient operations, the TCC installed 68 closed circuit television (CCTV) traffic surveillance cameras at the most critical arterial system intersections and near freeway ramps. The CCTV system consisted of a Burle Allegiant 8800 series switcher, Burle Color Cameras with 10X zooms in nitrogen filled environmental enclosures, and heavy-duty pan-and-tilt bases. Camera video and control communicates with the local field hubs on an Optical Cable Corporation multimode fiber using IFS 4700 WDM (wave division multiplexing) transceivers.

From the hubs, camera videos are multiplexed by ALS components and the multiplexed video is sent by laser to the Trafficenter on one single-mode fiber. At the TCC, the multiplexed signal is de-muxed and sent to the switcher unit for distribution to various monitors. Daisy-chained RS-442 camera and pan-and-tilt control codes are transmitted from the TCC to the camera via localized hubs along the single-mode fiber. A match in the communication i.d. and the address i.d. that is pre-set in each camera receiver determines the requested camera and pan-and-tilt responses. Figure 2 shows the TCC in operation.

Figure 2: Honolulu's Traffic Control Center

Honolulu's first CCTV phase was completed in 1996. In February 2000, DTS completed a phase that expanded the geographic coverage of traffic monitoring by ten miles in the direction of Moanalua Freeway and along two state highways paralleling H-3 north of H-1 (see Fig. 1). This phase increased the number of cameras from 68 to 88. The next phase, which began in March 2000, called for additional 44 cameras, raising the total to 132, and an additional five miles of surveillance. This phase would add the capability for video monitoring and operational control over the most critical traffic locations and areas of recurring congestion in and out of the Honolulu CBD.

The CCTV camera system is based completely on a fiber communications backbone. This is a highly desirable feature for any transportation agency because the backbone and network structure can also be utilized for other ITS elements such as transit and traveler information applications.

Although the Honolulu system is completely based on fiber, the Trafficenter has investigated non-fiber systems as well. These systems are especially useful where spare twisted-copper pairs from existing traffic signal inter-tie cables are available. Based on this investigation, DTS found the Mil-Lektron system to be an excellent, reliable, and user-friendly system for those who may not have the fiber option. Also, at the time of this writing, the TCC is investigating the application of wireless communication to allow temporary and/or permanent deployment in remote areas that lie outside the extent of the fiber-optic network.

Included among the benefits routinely derived by the TCC from the implementation of the CCTV system are the following:

- Comparison of traffic conditions and levels on alternative routes.
- Real time monitoring and analysis of entire routes simultaneously.
- Real time monitoring of parallel routes (e.g., freeway and arterial)
- Ability to check signal offsets with real-time flow conditions of platoons and to make appropriate adjustments when warranted.
- Ability to confirm and validate operations immediately after downloading new timing plans to local controllers.
- Quick determination and confirmation of peak hour and recurrent-congestion periods for designing weekday and weekend timing plans.
- Identification and verification of non-recurrent conditions or incidents and decisions on counter measures.
- Availability of videos for off-line traffic and pedestrian studies.

- Ability to monitor transit-vehicle movements and schedule adherence throughout the day.

- Documentation of real level of service conditions when responding to public concerns.

The Internet Connection

In 1996, an impromptu discussion between TCC staff and University of Hawaii College of Engineering (COE) personnel led to the idea of developing jointly a traffic camera web-based site (www.eng.hawaii.edu/Trafficam). The web service would focus on providing traveler information by capturing images from the videos that were coming into the Trafficenter from the field. Using only internal staff, a strategic alliance was forged between the TCC and the COE.

Initial Implementation

At the time of initial implementation, a fiber-optic connection between the Trafficenter and the University of Hawaii was not available. Consequently, images were captured on a PC located at the Trafficenter and transferred over a modem connection to the COE web server. A commercially available off-the-shelf image capture device was interfaced from the PC to one of the monitor ports of the video matrix switch and the PC's modem was connected to a standard telephone line.

The software included in the off-the-shelf package ran under the Windows operating system. It had the functionality to capture still images from video, to compress them into JPEG files, and to transmit the compressed files via the file transfer protocol (FTP) to the web server located at the COE, approximately two miles away from the TCC. The software, however, could not be configured to send commands to the video switch in order to control camera selection. To get around this problem, the video switch was programmed to cycle through a set of initially seven but soon after eight cameras with a hold time of one minute per camera. The software was correspondingly configured to cycle through a set of eight JPEG files, each file having been assigned a unique name matching the source camera identification. The reason why only eight cameras were placed in the sequence was related to the length of time required to complete a cycle. An eight-minute image refresh time was judged to be reasonable. The original seven cameras were located along the most congested segment of H-1 Freeway, whereas the eighth was in Oahu's famous Waikiki Beach area,

To allow camera images to be stored in the correct JPEG files, the initial capturing arrangement required the video switch and the image capture software to be well synchronized. This was done manually by starting the software when the video switch was at the beginning of the designated sequence. Unfortunately, the clocks on the PC and the video switch could not be kept constantly synchronized and drifts in the clocks caused

the software and video switch sequences to fall out of phase. After about a day of continuous operation, the drift would be long enough to cause the images to be stored into the wrong files. This meant that Internet users would be served the wrong image when selecting a particular location to be displayed in their web browsers. To minimize this problem, the two sequences had to be manually resynchronized once or twice a day.

Customized Software Development

To resolve the problems discussed above, the team developed customized software to control both the video capture device and the video switch. This enhancement allowed the software to select cameras on its own, obviated the synchronization problem, and reduced sequence cycle times significantly.

Initially the customized software did not transfer images to the COE web server directly. A PC NFS server software application was installed on the PC to make files available and the PC's file system was mounted on the unix-based web server at the University to access the files. Although not recommended, this approach allowed the software to work without having internal file transfer capabilities. The NFS server, however, slowed the PC down and sometimes caused Windows to run out of system resources. To rectify this problem file transfer capabilities were added to the software and the NFS server software was removed from the PC. As a result, system performance and reliability improved dramatically.

Fiber-optic Connection

A quantum jump was taken in late 1997, approximately one year after launching the web site. At that time, a fiber-optic link was extended from a nearby street approximately 100 feet to the College of Engineering at University of Hawaii. The investment in this by TCC was motivated by the overwhelmingly positive reception of the web site by residents and visitors alike, including cyber-visitors from throughout the world.

The video matrix switch, of course, remains at the Trafficenter. Video outputs from cameras located at various street locations are routed to the switch over fiber-optic communication links. The video capture equipment was moved to the COE although in a different building than the one that houses the COE web server. The video capture hardware is connected to the Trafficenter's video switch through the new fiber-optic communication links.

Still-Image Capture Hardware

The hardware used to provide still images on the Internet includes the initially acquired 200 MHz Pentium PC with 32 MB of memory configured with a 10Base-T Ethernet controller and the parallel port video capture device described earlier. This PC is connected to the video matrix switch through a serial RS-232 connection. One of the video monitor outputs from the matrix switch is connected to the composite video input of the image capture device. The video matrix switch can send any of the 88 traffic video

cameras to any of the 33 video-output ports that are currently in use on the switch. Text-based commands strings can be sent on one of two RS-232 command ports to select a camera to any of the video monitor ports. The web application uses one of these command ports for camera selection. Of the 33 video-monitor ports, one is used for still image capture and another three for streaming live video over the Internet; a feature added a year later in August 1998.

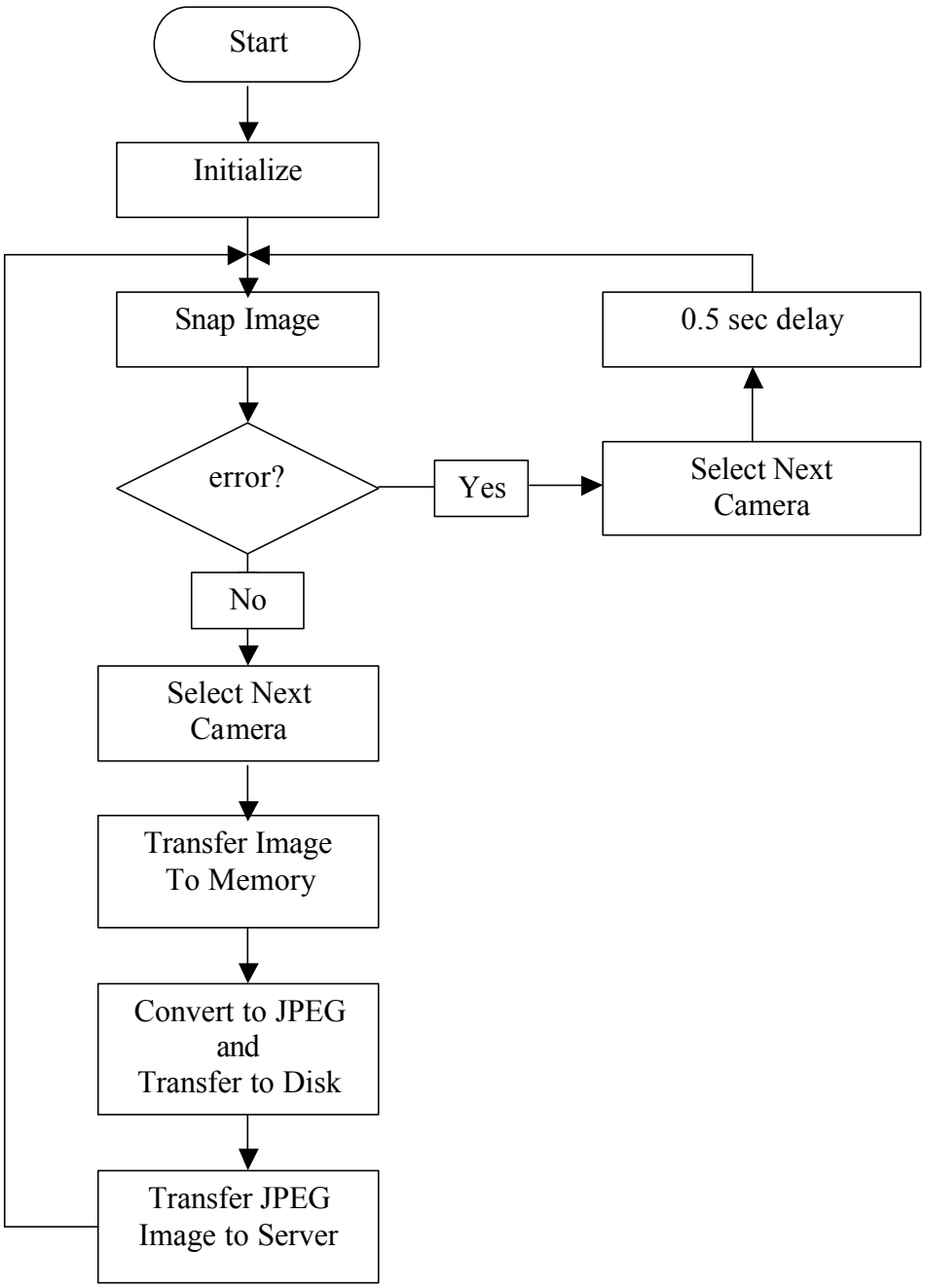

Figure 3: Image Capture Software

Still-Image Capture Software

The internally developed software application that controls capture of still images from any subset or from all 88 traffic cameras was written in C++. The software uses the development libraries that came with the video capture unit and the public domain JPEG libraries. The development libraries use callback routines to provide status information to the calling program.

The image capture program chooses the camera to digitize by sending "select" commands containing the camera identification number to the switch over its RS-232 command port. The order in which the program sequences through the cameras is determined by the position of each camera's identification number in an operator-specified configuration array.

A flow chart for the application is shown in Figure 3. After the image capture device is initialized, a command is sent to the video switch to select the first camera in the sequence, the JPEG compression routines are initialized, and a network connection is established with a file transfer server application running on the web server. The application uses the image capture device to snap a still image and to transfer it to the PC's memory for processing. A callback routine is used to notify the program when an image has been captured and a second callback routine is used to notify the program after the image has been successfully copied to the computer's memory. The image stored in memory is then compressed into a JPEG file with the JPEG quality parameter set to 90 and stored on the PC's hard drive. A copy of the JPEG file is then transferred to the web server over a 10mb/s Ethernet connection using the TCP/IP network protocols.

If the video input to the image-capture device is either low or absent, the image capture device reports an error using a callback routine. The program then selects the next camera in the sequence and sends a 0-byte file to the web server. Thus, a 0-byte file indicates that no image is available for that particular camera. When a web user requests a page containing 0-byte image(s), the web server has been programmed to use rewrite rules to replace 0-byte files with a special icon informing the requester that a camera image is not available.

MPEG Animation Feature

A special feature was added to the still-image capture program that allows us to designate any number of cameras (via toggle switches) for the preparation of MPEG animation movies. If a camera is so designated, an operator-specified number of images captured in sequential cycles are saved to disk in a folder that is dedicated to that camera. Once the specified number of images is reached, a routine converts the images to an MPEG file that becomes available for view through an active link in a visitor's browser. To create the MPEG file from the JPEG image files, the files are first ordered by date and time, then converted into a MPEG file using a public domain software application.

Streaming Video

Steaming video was added to the web site in August 1998, thus making the Honolulu Traffic Camera System one of the very first traffic information sites to offer real-time video.

The setup for this feature is straightforward. A popular commercially available streaming video server software application is used. The software runs on a dual processor 400MHz Pentium II PC with 384MBs of memory. Three video capture cards with National Television Systems Committee (NTSC) composite video inputs are also installed in this computer. The software video encoder creates a video stream for each of the video cards and feeds the video streams to the server for access by Internet users.

The video inputs for the cards are connected to the monitor outputs of the video switch located at the TCC. Each monitor output cycles through a set of cameras with each camera in the sequence selected for a period of ten seconds. As of March 2000, three monitor ports on the video switch were used to cycle through three selectable sets of cameras.

At that time, one real-time video sequence was configured to cycle through cameras located along the most congested section of the H-1 Freeway. The second video cycled through cameras located along a parallel arterial route, and the third was set to display cameras along a suburban route from the east end of the island of Oahu (Fig. 1) to the beginning of H-1 Freeway. This choice allowed web users to compare the traffic conditions between the parallel freeway and arterial routes in real time, and to assess the current conditions along the suburban route. Expansion of the number of real-time video feeds would require additional or more powerful hardware.

Initial Web Presence

The Honolulu Traffic Camera System web pages do not constitute a "site" in the strict sense of the word because they are hosted on the main COE server. This paper, however, uses the term "Trafficam site" for the sake of convenience.

The first version of the main (home) page was the quintessence of simplicity. Its core element was the rudimentary symbolic map of the segment of H-1 where the seven of the eight included cameras are located (shown in Figure 4). The horizontal line symbolized the extent of H-1 covered, and the red marks designated the camera locations in relation to either on- or off-ramps to the arterial network. Links to the same cameras were also included on the main page to accommodate browsers that had no image map functionality and a prominently displayed notice warned visitors about the synchronization problem discussed earlier.

Figure 4: Initial Graphic User Interface

By clicking on a camera mark (or, alternatively, on a text link), the typical visitor would wait for the selected snapshot to be displayed on the top page, assuming that the image-capture software and the matrix switcher were reasonably synchronized. It must be remembered that at that time most members of the general public with access to the Internet were on very low bandwidth connections and that their web browsers (e.g., *Mosaic*, the precursor of *Netscape*) were still limited in their functionality. Some people had access only to text-based browsers such as *Lynx*, whereas others were still content with the *Gopher* rather than the *World Wide Web* (HTTP) protocol. For example, tables and frames were not as widely supported, to say nothing about scripting languages and other advanced features. Nevertheless, the novelty of the Trafficam site attracted a surprising number of hits and the site's e-mail inbox was often flooded with message ranging in tone from unbounded admiration, to complaints about slow connection speeds, to requests for more cameras or alternate camera zoom, pan and tilt settings.

Figure 5: The First Map-Based Interface

Partly in response to suggestions from visitors to the site, the simple map interface was replaced with a base map of the area. This map was composed and downloaded from an

advanced, for that time, *Tiger Map Generation* web site operated by the U.S. Bureau of the Census. Manually superimposed on the base map were large-font street names and camera icons that, in a subsequent iteration, were color-coded and oriented to indicate the direction in which the real cameras were normally pointing (Fig. 5). Incidentally, the Census map-generation site is still in existence [2].

The original JPEG map image has since been lost to subsequent modifications but a GIF formatted version of it was fortunately preserved (Fig. 5) on the web site of a Honolulu evening paper under the headline: *How's the Traffic? Check the Net* [3] in a story that partly read:

> *So if you want to check to see if it's safe to actually drive to the airport at lunch, the Internet can help you out. Or if you're in Slippery Rock, Texas, wishing for the urban congestion of Honolulu, you can visit without denting a fender.*

By then the visitor base had become international. The number of daily visits showed a steady rate of increase and links to the site were being added on personal home pages and other sites worldwide. A quantum jump was observed almost instantaneously following a decision to include a camera that pointed toward the beach in Waikiki.

With very few guidelines regarding proven and intuitive web-based traffic camera graphic user interfaces (GUIs) to go by but with many suggestions from visitors to the site, several alternative designs were tested. These included a page that showed the entire set of cameras simultaneously and several pages that displayed subsets of the available snapshots. Clearly these were preferred by visitors with relatively faster links who were becoming impatient with having to click on an icon or a link to only receive one camera snapshot at a time. Another option that proved to be quite popular was one that was becoming somewhat of a standard among web sites featuring traffic cameras. In this design, the top frame (i.e., browser window) was divided into two sub-frames. One sub-frame contained a clickable map (a stretched out version of Fig. 5), whereas the other frame was the target for displaying the selected snapshot. This option required browsers that supported frames and client and/or server-side image maps.

Expanded Interface

The fiber-optic cable connection between the TCC and the COE made it possible to cycle through all 68 (and more recently 88) cameras in less than five minutes, depending on the complexity of the individual images. Consequently, the commonly employed simple (one-camera-at-a-time) user interface described above became cumbersome to use. Additionally, the Honolulu camera coverage differs from typical sites found on the Internet. Other web sites confine their cameras only to freeways and interstate highways with spacing in the order of miles. By contrast, most of Honolulu's cameras are located at surface street intersections and are spaced very closely, sometimes only a few street-blocks apart.

Based on feedback from site visitors, the most intuitive arrangement was one that grouped cameras by major street/route, respectively in the east-west and north-south directions as shown in Figure 6. The figure shows the current main Trafficam page that facilitates access to snapshots from 87 of the 88 cameras currently available and to other options. The pull-down menu bar at the top of the page was added, at the request of several users, in early 2000. This menu bar appears on all display-pages, thus making it unnecessary for the users to have to return to the main page in order to make their next selection. The pages displaying snapshot images are configured to refresh automatically every three minutes.

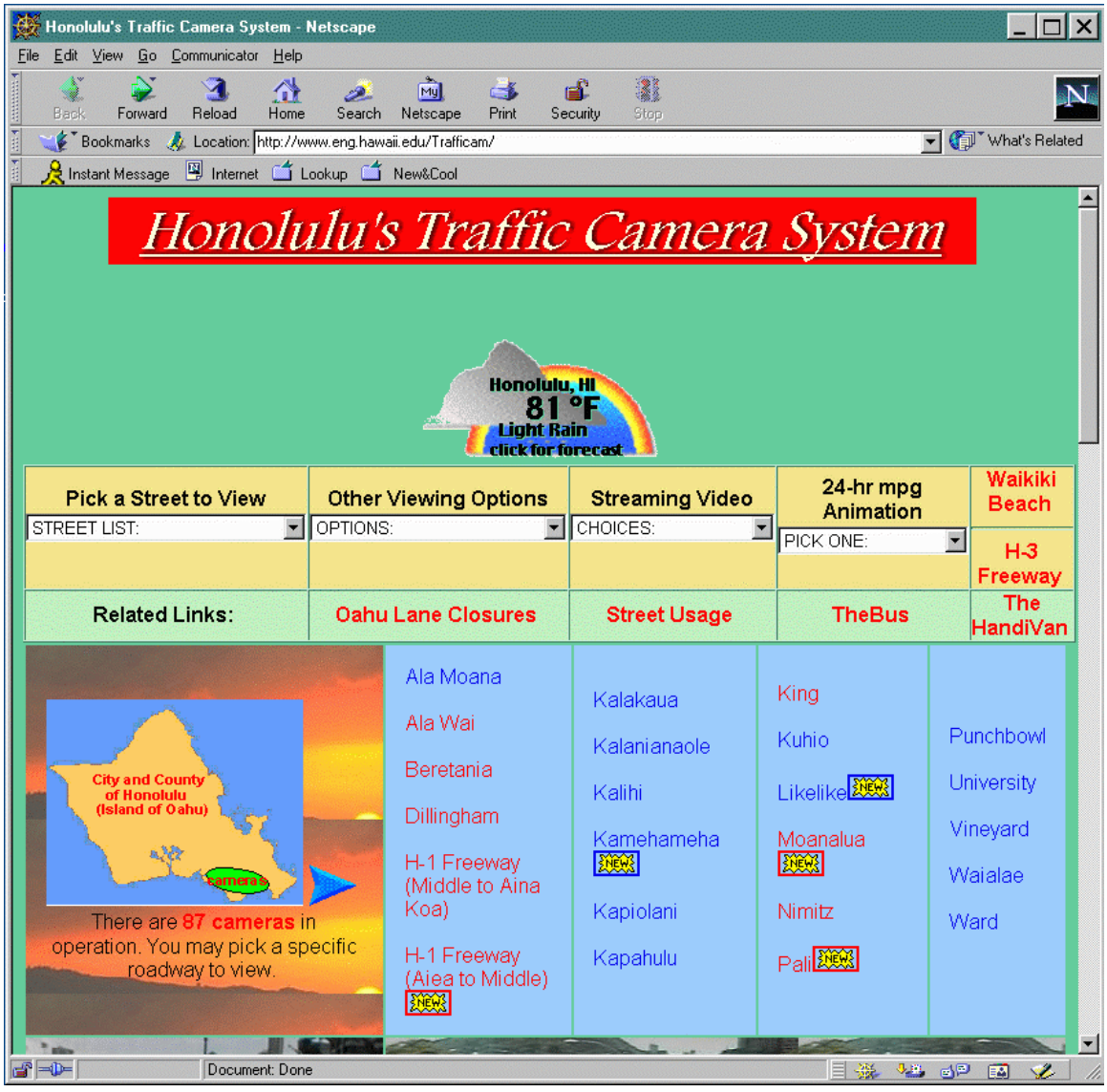

Figure 6: Top Portion of the Current Main Page

Also added to the menu bar at about the same time were links to transportation related pages maintained by other organizations in Honolulu that earlier appeared only as text-based links on the main page. The link to the H-3 Freeway connects to a separate "site" that we also developed. This site features eight cameras along the new freeway obtained (due to lack of fiber-optic connectivity) via telephone line from the State DOT's control facility. A PC located at the control facility approximately eight miles from the University runs a version of the image capture software described earlier, modified to communicate with a different matrix switcher than the one used by the Honolulu TCC.

Figure 7 illustrates the middle portion of the main page. This part presents the options of viewing streaming video from three routes (Nimitz-Ala Moana, H-1 Freeway, and Kalanianaole Highway), 24-hour MPEG animation from two cameras (the very busy section of H-1 Freeway at Ward Avenue, and Waikiki Beach), and a connection to the H-3 "site" described above.

Figure 7: Middle Portion of Main Interface

Figure 8 shows bottom portion of the main page and illustrates other viewing options (some of which are also found in the pull-down menus at the top of the page) and links to related sites described above. Also included at the very bottom of the page but not shown in the figure are an e-mail submission button, an acknowledgement of the cooperating organizations, and a link to a web page that lists the numerous kudos and awards earned by the Trafficam site.

Figure 8: Bottom Portion of Main Interface

Among the alternate viewing options shown are

- frame-based image map, one-camera-at-a-time displays for several routes
- the original clickable map (shown in Fig. 5) enhanced with the Waikiki camera
- a common gate interface (CGI) based user-selected camera option where the user toggles on a subset of cameras to be displayed simultaneously on the same web page

- a one-camera-at-a-time option that was implemented via a javascript-based floating-frame remote navigator

The banner at the bottom of the figure presents slow and fast links to public service video announcements that the team digitizes from analog TV videos and includes at this point for dissemination to the public. The particular announcement shown is titled "Drive with Aloha" and is intended to discourage road-rage behavior. It features two local television personalities and the mayor of Honolulu.

Typical Uses of the Trafficam Site

Frankly speaking, the Trafficam team was initially ambivalent about the potential usefulness of the web site. However, it soon became clear that visitors to the site were finding the system useful and that many of them had become dependent on it. The precise degree to which this usefulness is real or perceived is not fully understood. There is, however, clear evidence that some highway users do in fact use the cameras to modify their travel choices. Most often, they attempt to avoid peak-period congestion by adjusting their departure times from home and work, and they await a return to normal conditions following major incidents prior to getting on the road. A sampling of e-mail messages volunteered by highway users describes these reactions in their own words:

- *I find these cameras a great asset, every morning before leaving for work, I check your site/cameras. Thank you!*

- *I use the Middle St. video to decide when to get in my car and head to town from Aiea, so I appreciate having this site.*

- *Today there was a car fire in the H-3 tunnel, and I was able to adjust my driving plans to avoid the mess. Using your web site I was able to determine when the tunnel re-opened.*

- *Hi, Really like this sight I use it to check out the Weather since I ride a Motorcycle and I live on the windward side.*

More Is Not Enough

Before extending the camera coverage west of the Honolulu CBD and to the north of H-1 Freeway, we received numerous requests for expansion such as,

- *Are you going to be installing cameras at H-1/H-2 and other locations along the "Bermuda Triangle"?*

and

- *the main decision in my afternoon commute from town to Ewa is whether to take Moanalua or H-1. Will there be any traffic cameras available in this area in the near future?*

Following the installation of cameras in the above areas and on the town-side of Likelike and Pali Highways that lead to windward Oahu,

- *Your new cameras west bound, Likelike, Pali, are great. Makes route planning a lot easier.*

But also,

- *Are there any plans in the works for the windward area?*

and

- *As a taxpayer of the City of Honolulu I would like to say first of all good job. Now could you please create more streaming video sites, for example downtown area, Kalihi area, and Vineyard area.*

Cyber-Taxi

An independent taxi driver who invested in a notebook computer and a cellular phone devised an innovative in-vehicle use of the Trafficam site. He attached a shelf to the dashboard of his taxi for the computer and connected to the Internet via the cellular phone thus allowing him to view roadway conditions at any time. Initially, he connected the cellular phone to the notebook via the RS-232 port. Subsequently, he replaced the computer with one equipped with a Universal Service Bus (USB) that allowed him to connect to the Trafficam site and to a global positioning system (GPS) receiver and a commercially available digitized map of Honolulu simultaneously.

In his own words [4],

Aloha State Cab No. 10 is Hawaii's first public transportation vehicle to utilize Honolulu's Traffic Camera System. All … cameras are viewable from the dashport of the taxi. No more guessing what the traffic is on the road ahead. Now you can see it. Is the H-1 Freeway clear all the way to the airport? The Taxi knows. The reaction of my customers is disbelief. No other city that I know of has anything like this. When I pick up a passenger in Waikiki going to the airport, by the time I get to Ala Wai and McCully, I know whether to take the freeway or an alternate route.

The taxi driver is quite aware of the need to exercise extreme caution when using his set-up en-route. He reports that the automatic refresh feature of the web pages reduces the keystrokes required.

Figure 9: The Cyber-Taxi In-Vehicle Set-up

Taxi Dispatch

The largest Taxi Company in Honolulu uses the Trafficam site to aid in its dispatching operations. According to the company's president,

Since Charley's Taxi installed a dedicated computer for the Trafficam in our Call Center last week, our dispatchers are no longer dispatching "blind." They are now able to radio our taxi drivers when parades clear up from intersection-to-intersection, and when the freeway is bumper-to-bumper. Charley's drivers can now radio in their questions about traffic conditions before entering the freeway(s), or to avoid tie-ups further ahead on featured streets.

The Trafficam is practical because Honolulu's camera system covers major roadways throughout town, not only the state highways…

Figure 10: Taxi Dispatch Room Set-up

Our software developer from Calgary, Canada is so impressed by our practical application of Honolulu's traffic camera system, he plans to go back and ask the City of Calgary to install a similar system [5].

Figure 10 shows the Company's dispatch room featuring the dedicated computer in the center of the picture. The computer's screen contains a web page consisting of four still images. Streaming video is running in the upper right corner of the screen.

Technical Assistance

In the same vein, numerous inquiries have been received from many U. S. cities and state DOTs as well as internationally requesting assistance in implementing similar systems. A few examples are quoted below:

From New Haven, Connecticut:

I work for a TV station in New Haven, Connecticut. Our DOT has a network of 91 cameras along I-95. We are tapped into those cameras and can use any of them we want on air when there are traffic problems. Obviously, we would like to put them all on our website as well. I am curious to know a few technical questions, which may help us decide what kind of server/software to buy, or whether we need custom software made.

From New Orleans:

I'm looking for information about traffic monitoring systems for use in our region (the New Orleans area). Your site is an impressive example. Could you provide me a

reference to people or publications with more information about the technology and implementation of your cam site?

And from Western Australia:

Chromium New Media is currently tendering for the contract to provide traffic images to the Internet for the Western Australian Department of Main Roads. The system will be similar to that provided by the Honolulu Traffic System. Any technical information relating to the implementation of the Honolulu System would be most appreciated.

Regarding our streaming video functionality:

I maintain the traffic information webpage for the Washington State Department of Transportation ...We are receiving a number of requests to provide streaming video across the Internet to our users. Until recently, I felt that this was too bandwidth intensive to implement, not to mention expensive. Your site has given me hope that this is not the case! I would love to hear from your experiences as they relate to the following questions…

In addition to requests for assistance with web site development, other technical inquiries resulted from the visual nature of the service. For example,

We are looking into the possibility of introducing a pedestrian crossing similar to the one at the intersection of Kalakaua and Kaiulani Avenues. At these crossings the traffic is controlled from entering the intersection and pedestrians are able to cross in all directions. Do you refer to these as Scramble crossings?...Are you able to email me the criteria your Department uses to establish these types of crossings (for example, where may they be used and where shouldn't they be used) and a 24hr mpeg animation of the crossing?

Non-traffic-related Uses - The Medium Is The Message

In his famous 1965 dictum *The Medium is the Message* [6,7], Marshall McCluhan predicted that electronic media would have a profound effect on the "global village." He foresaw that they would not only cause incremental changes but that they would have a transforming effect on society as it adapted and integrated these media in ways beyond those envisioned initially. In a small scale, this phenomenon became evident after the introduction of the Trafficam web site. People immediately found unanticipated ways to use it, as illustrated by the small sample of verbatim comments that follows:

Expatriates find the cameras as a means to virtually visit "home":

- *THANKS! I used to live in Honolulu, I never thought that traffic could look so good. I hope to be back one day and fight it again. Aloha.*

Another ex-Hawaii resident (*kama'aina,* in the Hawaiian Language) said:

- *I know this is not the reason why the traffic cam system was put together and put on the net, but it's important to me: I used to be kama'aina, but now I am here on the East Coast missing everything about the islands. I used to hate sitting in traffic on H-1, but now I just sit and watch it on your site and wish I were there!*

A third Hawaii-born cyber-visitor's message from Japan states:

- *Aloha! Being born and raised on Oahu and now living in Japan, I visit your webpage everyday. It's the fastest way to feel the real-time warmth of Waikiki beach, glimpse H-1 freeway conditions and see the island's weather. It's like being at home.*

Returning and potential tourists to the islands use the site in similar ways:

- *As a visitor to the islands every year, I find your highway cameras a way to keep up to date on the highways around Honolulu. I love seeing what is going on while being over five thousand miles away in Florida. Whenever I see this site, I want to get on an airplane and go to Hawaii*

and

- *I live in NY State and I find your site a breath of fresh air. I know that sounds sick, but even seeing Hawaii's sun drenched highways make me long for the days of my honey- moon canvassing the islands in our rented Geo Tracker.*

Others appear to be more demanding:

- *People in New Jersey would prefer more beach scenes than scenes of highway traffic. There is plenty of traffic here, we do not need to see yours.*

A frequent visitor who enjoys the view of the entrance to his favorite hotel:

- *The camera got moved again at Kalakaua & Kaiulani, I cannot see the pillars at the Moana/Surfrider or the drive-thru entrance.*

The site has also been linked from many web sites featuring Hawaii, e.g.,

- *We are just about putting up a comprehensive German online-service for all those interested in the islands of Hawaii ... Therefore we would like to integrate one of your roadway live-images in our homepage*

and

- *We are planning to air a program in title Let's Surf & Surf on the radio (TOKYO FM Radio Station) on July 20. Concerning this matter, I am writing to seek your approval [to] create [a] link to your home page as our recommended site on the TOKYO FM home page.*

The variety and scope of the comments and inquiries submitted over the years are sufficient to form the basis of a very interesting socio-cultural study!

The Famous Waikiki Camera

In 1996, the Office of the Oahu Civil Defense requested of the TCC to pan a camera located in the Waikiki area of Honolulu toward the ocean in order to monitor predicted high-surf conditions for several days. After the danger passed, the camera was re-oriented to its normal direction facing a main street. This action elicited strong opposition as illustrated by the following message:

- *What happened to the Waikiki beach cam? I used it to check the surf, but now it points to the street! Yes, I realize this IS the Traffic Camera System, but the beach cam was very useful. I hope there is a way to restore this service*

Responding to overwhelming numbers of similar requests, the TCC decided to keep the camera facing the ocean and to add a second camera pointing at the street. Before long, posing at the Waikiki Beach camera became a "thing to do" while visiting Honolulu, to wit:

- *I am headed for your Island for the Marathon in December and I would like to know how quickly your traffic cams update. I'm especially interested in the traffic cam that shows Waikiki beach. I am trying to organize about 100 runners to stand on the beach on the afternoon of Dec 13th so all our fellow runners throughout the world can see us.*

Similarly,

- *My Wife and I will be venturing to your Islands on Oct 7th. In researching for our trip, I came across you "View Waikiki Beach" page. We have pinged it many times to catch different views of the beach. My company is really heavy into IT work (this is not a sales pitch!). So my office has asked me to do something that may seem incredibly "geeky". They would like for me to find out where the Waikiki Beach camera is located, stand in its path, and call them on my Cellular phone so that they can hit the page and see me. I know it sounds a bit weird, but, hey, we work in a dark room and don't get out much. Thanks!*

and

- *My sister and brother-in-law just got back from an 8-day trip to Waikiki for their 20th anniversary. We set up a time and they stood in front of the Waikiki beach cam and waved to us here in Seattle. When we picked them up at the Seattle airport, we handed them the photos.*

On June 21, 1998 the Waikiki camera captured the passage of the *USS Missouri*, the *Mighty MO*, on its way to Pearl Harbor where it has since been converted into a World War II museum. It was on the deck of this battleship that Japan formally surrendered on September 2, 1945 thus signifying the end of Word War II. The ship is moored a short distance from the sunken *USS Arizona* below the Arizona Memorial that commemorates the entry of the United States into the war following the attack on Pearl Harbor on December 7, 1941.

Conclusion

For a very modest investment in hardware and software, the TCC and COE were able to provide to the general public a variety of snapshot and streaming video images that were already available at central control. The Trafficam web site was readily welcomed by the driving population as a means of informing them about traffic conditions in real-time. Others found a myriad of non-traffic related uses for the service. The majority of highway users visiting the site find it useful for pre-trip planning purposes, particularly in terms of route choice and trip departure time. With the rapid increase in Internet bandwidth capacities, web-based traffic camera services are becoming increasingly common. The Trafficam service is currently being extended to deliver real-time transit information over the Internet as well by informing transit users about the location and arrival times of transit vehicles through the use of combinations of positioning technologies (e.g., global positioning system, dead-reckoning and roadside transceivers). Comprehensive traveler information systems will undoubtedly require additional components, particularly for en-route information delivery, such as advisory radio, in-vehicle navigation systems and the like.

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