Design a Smart Bus System

ELEC 399 Progress Report II

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Group No.	**8**	
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Glossary

APC	Automatic Passenger Counting
GPRS	General Packet Radio Service
GPS	Global Positioning System
LCD	Liquid crystal display
LED	Light-emitting diode
RF	Radio frequency
SBS	Smart Bus System
VGA	Video Graphics Array
VRTS	Victoria Regional Transit System

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Chapter 1 Design a Smart Bus System

1.1 Project Overview

1.1.1 Project Description

Project title: Design a Smart Bus System

Supervisors: Dr. Fayez Gebali, Dr. Kin F. Li and Dr. Michael McGuire

The Smart Bus System (SBS) project is initiated in response to course ELEC 399 Design Project I at the University of Victoria (UVic) in May 2012. The project is supervised by three faculty members at UVic's Engineering Department - Dr. Fayez Gebali, Dr. Kin Li and Dr. Michael McGuire. By late July 2012, a presentation and a project report featuring a product definition and a detailed system design will be delivered to the department. Due to limited time, a prototype of only one component of the entire system – a smart bus stop - will be implemented by April 2013, in response to course ELEC 499 Design Project II.

Team *Connec4* is a group of four undergraduate students from the University of Victoria's Department of Electrical and Computer Engineering who are enthusiastic in applying communication technology to improve public transit user experience.

1.1.2 Motivation

Victoria Regional Transit System coordinates the delivery of public transportation throughout Victoria. The current transit system in Victoria has not kept pace with more modernized systems where real-time transit scheduling and traffic data are accessible to the general public. It is not rare to encounter frustrations when buses are not arriving on pre-made schedules due to real-time uncertainties. On the other hand, emerging personal communication and computing technologies, such as Smartphone, are fast growing popularity worldwide with hundreds of millions users. To resolve the imbalance between the current system and the ever-evolving technology, it is innovative to enable effective communication among the transit control center, buses, bus stops, and passengers.

The Smart Bus System (SBS) is a system which applies available communication technologies (e.g. GPS,) to connect transit authority and passengers. It provides the public with an easy and comfortable way of travelling. Especially in Victoria, a city that hosts a large non-local student population who highly rely on the public transit, the availability of real-time transit data would be largely beneficial. For example, an accurate real-time scheduling would reduce students' tardiness, allow better time management, and offer easy navigation around the city.

Besides students, Victoria has an aging population. In the years to come, Victoria will experience an influx in transitions from cars to public transit. Due to the uncertainty and unreliability of the static schedules and the lack of information on bus routes, people tend to feel intimidated to the bus alternative and more likely prolong car use which gives more freedom. By making real-time transit data available and maintaining a high level of accuracy, the discouragement could be removed. People should feel the bus system is catered to their personal schedules despite being held to the bus schedules.

Besides students and senior citizens, an inclusive transit system would provide accommodations for people with special needs. For example, a Smartphone app with vibrating functions could be developed to alert people with visual impairment. Also, the availability of wheel-chair space could be accessed on computer, at bus stop, or via phone. Advancements like these and others will make it easier to use public transit and provide individual freedom.

1.1.3 Goal

The project goal is to explore ideas of integrating the Victoria Regional Transit System with appropriate communication technologies and to develop a corresponding Smartphone app. In a SBS, users can access real-time passenger information such as schedules, trip planners, bus capacity estimates, bike rack availability and bus stop locations, via Smartphone, on computers and at bus stops. This system would be inclusive to all users including people with special needs.

1.1.4 Objectives

The project objectives include

a. To explore wireless technologies to connect buses, bus stops, and users;
b. To propose buses and bus stop infrastructure to support the desired functionalities;
c. To develop user-friendly interfaces for accessing real-time transit data;
d. To assist people with special needs in travelling independently by public transit systems.

1.2 Project Milestones

A detailed project plan with dates is summarized in Table 1 and Figure 1.

Table 1: Project milestones

Task	**Planned Completion Date**	**Actual Completion Date**
Complete background and market research	12-06-15	12-06-12
Define product definition	12-06-19	12-06-13
Set list of alternatives	12-06-23	12-06-23
Review alternative options	12-06-24	12-06-23
Select alternative	12-06-24	12-06-23
Contact potential associates	12-07-06	12-07-05
Compose preliminary components list – includes company, delivery times, price, possible design	12-07-06	
Analysis 1 – Costs/Implementation	12-07-13	
Analysis 2 – Benefits/Comparisons	12-07-13	
Revise components list	12-07-15	
Final design process – step by step plan, prototype design	12-07-22	
Finish implementation scope	12-07-29	
Group presentation	12-07-31	
Final report	12-08-03	

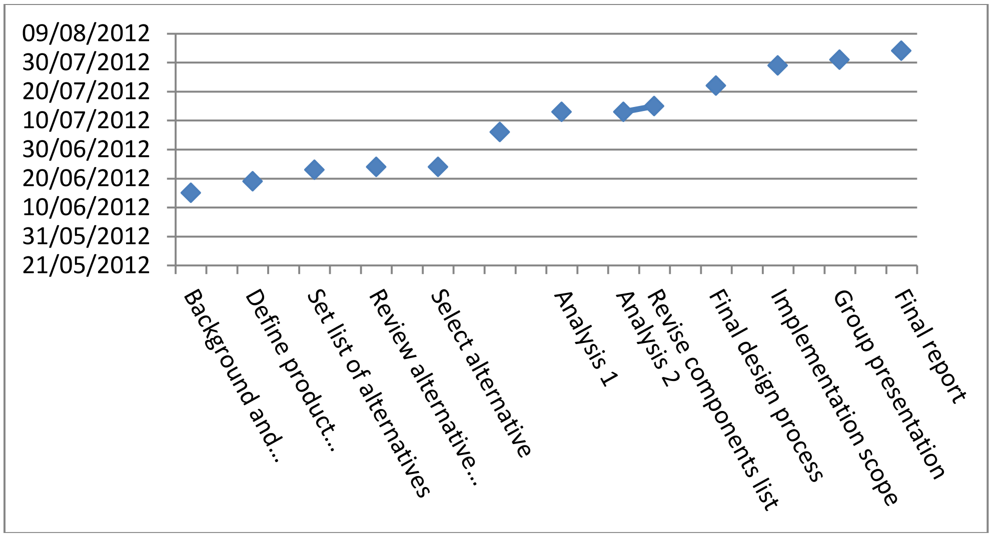

Figure 1: Project milestones

1.3 Project Deliverables

For the project, a list of deliverables to be produced by August 2012 was created as shown in Table 2.

Table 2: Deliverables

Deliverables	**Status**
Background/Market research – specs.	Done
Project proposal	Done
Product definition	Done
Alternative analysis	Done
Prototype design	
List of HW/SW components	
Cost/Implementation analysis	
Benefits/Comparisons analysis	
Implementation scope	
Report	
Presentation	
Website	Launched

1.4 Biography

1.4.1 Team Members

Team *Connec4* is a group of four undergraduate students from the University of Victoria's Department of Electrical and Computer Engineering who are enthusiastic in applying communication technology to improve public transit user experience.

Xiaoya Guo (Jessie)

Jessie is a 4^{th} year Electrical Engineering student interested in power system and sustainable energy solutions. She is sure that the idea of a smart transit system in Victoria will encourage more people to use the public transit and lead to a greener future. Her past Co-op work experiences include digital medical image processing at the BC Cancer Agency, technical support at AbeBooks.com, transmission system modeling management at Alberta Electrical System Operator, and electrical substation design at BC Hydro. In her spare time, she enjoys working out and outdoor activities.

Emily (Chu Feng) Huang

Emily is a third year Electrical Engineering student interested in digital signal processing. She believes that the design of smart bus stop could help out passengers with disabilities and give the public ample guidance when travelling. She had experienced different transit systems while she resided in Singapore and Taipei; therefore she could use her personal experiences as research reference. She also has fundamental knowledge of programming languages such as C and JAVA so she could help implementing the communication system of smart bus stop. With the previous experience working in EcoCAR team, she has basic knowledge of car structures. In her spare time, she enjoys participating in charity organizations' fund raising events and doing community service. Therefore, she could constantly speak to people with disabilities to understand their needs.

Ping-Hsiang Hung (Benson)

Benson is a 3^{rd} year Electrical Engineering student interested in embedded system and network security. He worked with computer vision development in AUVic, submarine hazard research at the Geological Survey of Canada, forest fire analysis and management at the Canadian Forest Service, and university website maintenance support at the University of Victoria Communication Services. Currently he acts as the project coordinator for the AUVic team and manages team outreach, website, recruitment, as well as computer system development for the autonomous underwater vehicle. He enjoys foil fencing and sabre fencing during his spare time and attend fencing tournaments sometimes. He has experienced the semi-smart transit system before; therefore he understands that the smart transit system project will give the public more conveniences by improving the current transit operation and providing timely bussing information.

Lara Juras

Lara is a 4th year electrical engineering student specializing in electromagnetics and interested in optimizations in technology that can improve everyday practices and allow her to be creative. This project captured her interest since it is innovative and involves design freedom. She also is excited about the communications aspect and applying course work. Lara brings her previous work experience to the group from assisting project managers at ASYS GmbH with a solar panel machine line project, acting as a project coordinator with the hardware development project managers at Research in Motion and working with databases in the electrical team at Lafarge Canada Inc. Not to mention, her travel experience across the world (e.g. Germany, Spain) provides invaluable insight to current technologies in public transportation systems. This also means she understands the insecurities people may feel in an unfamiliar area and recognizes the need for a "Smart Transit System." In her free time, she enjoys practicing yoga and pilates, viewing films and traveling to new countries to experience the culture.

1.4.2 Supervisors

Dr. Fayez Gebali

Dr. Gebali received his B.Sc. in Electrical Engineering (first class honors) from Cairo University, his B.Sc. in Mathematics (first class honors) from Ain Shams university, and his Ph.D. degree in Electrical Engineering from the University of British Columbia where he was a holder of an NSERC postgraduate scholarship. Dr. Gebali is a Professor and Chair of the Department of Electrical and Computer Engineering at the University of Victoria. His research interests include parallel algorithms, networks-on-chip, three-dimensional integrated circuits, digital communications, and computer arithmetic.

Dr. Kin Fun Li

Professor Kin Fun Li has earned bachelor and doctoral degrees in computer engineering and master's in business administration. He is the Director of Computer Engineering Program at the University of Victoria, Canada, where he teaches both hardware and software courses in computer-related areas. His dedication to teaching brought him numerous student-initiated awards. Li's research interests include computer architecture, web searching and mining, and application specific hardware. He is actively involved in the organization of many international conferences in these research areas. Besides teaching and researching, Li, a senior member of IEEE, initiates, supports and participates in numerous international activities to promote the engineering profession and education.

Dr. Michael McGuire

Michael McGuire received his B.Eng. in Computer Engineering from the University of Victoria in 1995. He remained at that university until 1997 to complete a Masters degree in Electrical Engineering, developing Fuzzy Logic based algorithms for hand-off control in wireless cellular networks. After his Masters, he spent two years at Lucent Technologies at Holmdel, NJ. His projects included testing the first generation of multi-protocol cellular telephones and developing fault detection and management software for high capacity optical transmission systems. From 1999 until 2003, Michael enrolled at the University of Toronto to complete his PhD with the Digital Signal Processing group. After the completion of his doctorate, he then joined the faculty of the Department of Electrical and Computer Engineering at the University of Victoria. His research interests are signal processing for communications, model-based filtering, and non-parametric estimation. He currently holds grants from the National Science and Engineering Research Council of Canada as well as research contracts for industrial partners. Dr. McGuire is a member of the IEEE Communications, Computer, and Signal Processing Societies.

Chapter 2 Progress Review

2.1 Project Meetings and Milestones

Throughout the past month, the team attended five weekly supervisor meetings with Dr. Gebali, Dr. Li, and Dr. McGuire to discuss the progress and details about the project. Apart from the supervisor meetings, weekly progress meetings were held to compile progress and make future plans. Five project Milestones were achieved as summarized in Table 3. The project website was launched at http://www.ece.uvic.ca/~bhung/399/index.html.

Table 3: Milestones achieved to date

Milestones	Details
Complete background and market research	The current bus system in Victoria was investigated; Various intelligent transit system technologies were explored; Three case studies were conducted on the transportation system in Singapore, Taipei, and Winnipeg.
Define product definition	The product was defined as an integration of communication technologies and supporting infrastructures with the current bus system in Victoria to enhance the user experience.
Set list of alternatives	The alternatives included different communication technologies and infrastructures that could enable/improve communication among buses, bus stops, and bus system users. A list of desired functionalities along with the proposed technologies and supporting infrastructures was concluded.
Review alternative options	
Select alternative	

2.2 Contacting Potential Associates

On July 4th, the team emailed BC transit and CanAssist to arrange a meeting.

BC Transit coordinates the delivery of public transportation throughout BC (outside the Greater Vancouver Regional District). The team is interested in creating a partnership to learn about the current bus systems in the Victoria region, e.g. the current infrastructure, future implementations and district restrictions for technologies and data release. The team would like to assist and help move forward the technological advancements that will benefit bus users and the transit authorities.

CanAssist is an organization at UVic that develops products and provides services to help those with disabilities improve their quality of life. The team is interested in developing a partnership to learn about what special-needs people require when taking buses and what would give back individual freedom. The team would like to learn about the development of CanAssist's CanGo, a mobile tool for independent travel for people with cognitive disabilities.

2.3 Preliminary Design

To achieve the goal and objectives, a preliminary design of the Smart Bus System was proposed featuring functions of three categories:

a. On-board
b. Bus stop
c. Portable user interface.

2.3.1 On-Board

Figure 2 illustrates a preliminary design of a smart bus with on-board advancements. Firstly, with the "Next-stop" display and voice announcing system, passengers will know where they are and when to get off the bus. People unfamiliar with the route or area will be more likely to take buses as the announcing system provides a navigation guide. Secondly, the passenger data collected from the Automatic Passenger Counter (APC) will be translated into statuses for people to know the seat availability on a bus. The transit dispatch center can use this information to determine the need to dispatch extra buses during peak-passenger hours. Thirdly, sensors on bike racks will report the number of bike racks available. Cyclers will be more willing to take buses by knowing beforehand if bike racks are full. Lastly, through the on-board GPS device and the RF link, the transit center will be able to gather transit data collected from buses in real-time. A set of desired functionalities and proposed infrastructures are summarized in Table 4.

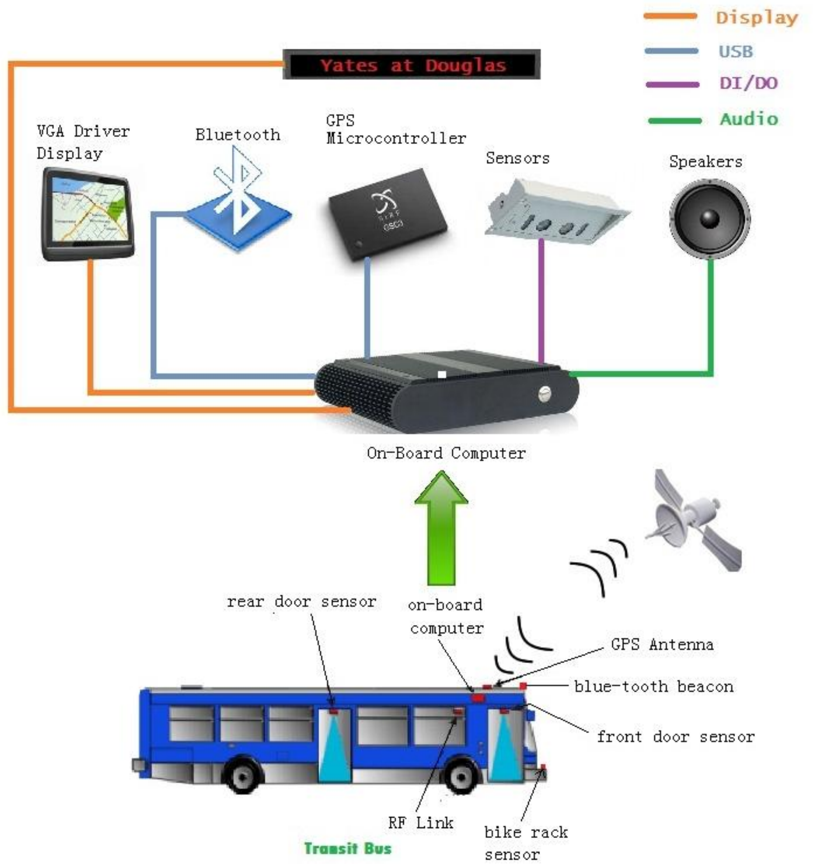

Figure 2: Smart bus

Table 4: On-board technology

Desired Functionality	Proposed Infrastructure and Technology
"Next Stop" announcement	LCD display Speaker
Real-time position tracking	GPS antenna GPS microcontroller chips
GPS navigation for bus drivers	On-board computer with VGA display
Inform the bus stop when bus arrives	Bluetooth beacon
Estimate bus capacity and availability	Automatic Passenger Counter (APC) Farebox
Report bike rack availability	Position or load sensors on bike racks
Communicating with transit control center	RF link implementing GPRS protocol

2.3.2 Bus Stop

Figure 3 illustrates a preliminary design of a smart bus stop. Real-time passenger information will be displayed at bus stops. Bus stops will be equipped with an RF link to receive data from the transit center, LCD to display real-time transit data, and a Bluetooth beacon to communicate with Bluetooth-enabled cell phones at the bus stop. As well, to increase safety, camera surveillance will be added and remote bus stops will have LED lights. Finally, all the real-time information will be available via website and a Smartphone app. Specifically, the app will feature real-time schedule, trip planner, bus stop locator and bus arriving alarm. The alarm will assist special needs people by alerting their phone when and which bus arrives. In more details, a bus stop will detect a Bluetooth-enabled Smartphone within a range and allow the app to transfer information displayed at the bus stop to the Smartphone. When the bus arrives, the bus stop will alert the person(s) at the bus stop using voice or vibration function of the cell phone and at the same time send a signal to let the bus know someone with special needs wishes to board. A set of desired functionalities and proposed infrastructures are summarized in Table 5.

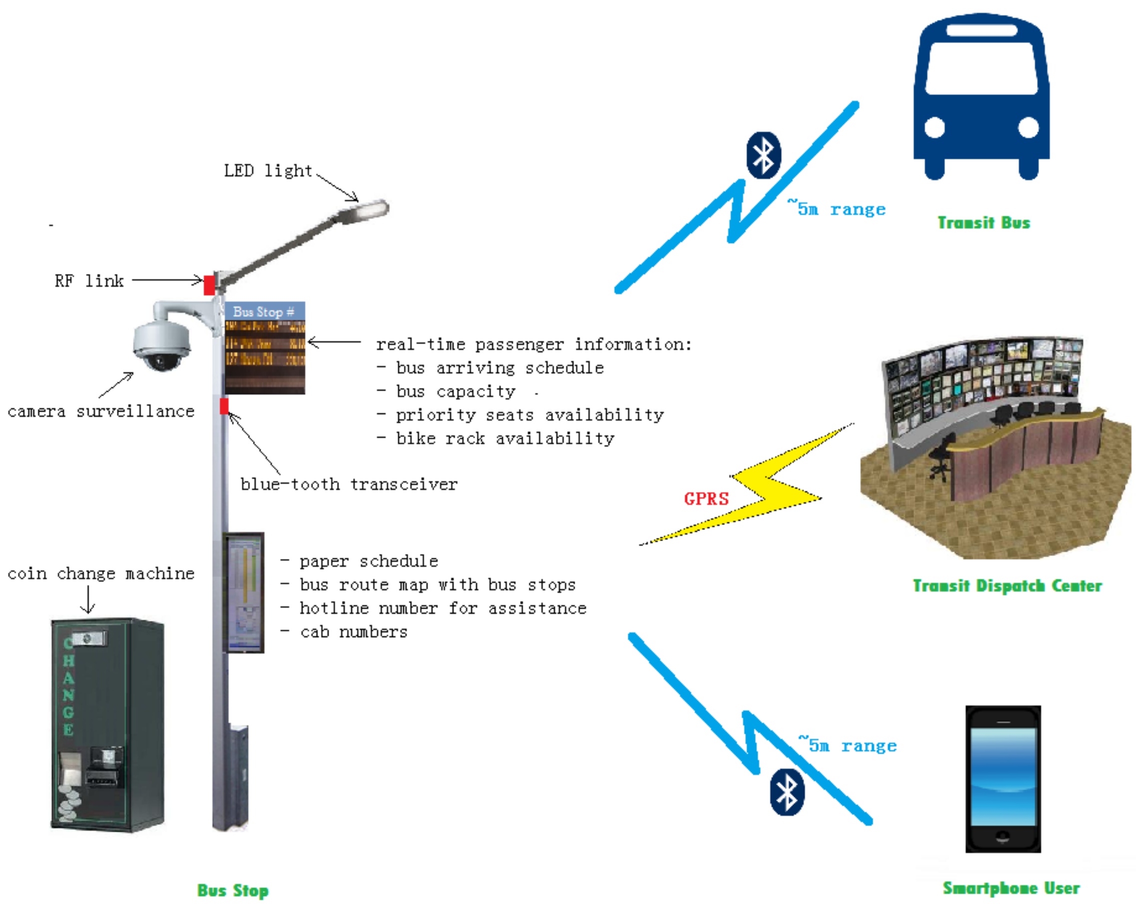

Figure 3: Smart bus stop

Table 5: Bus stop technology

Desired Functionality	Proposed Infrastructure and Technology
Receive real-time passenger information from the transit control center: **Real-time schedule** **Bus capacity / availability** **Bike rack availability** **Priority seats availability**	RF link implementing GPRS protocol
Display passenger information of next buses	LCD display
Short range communication: **Transfer passenger information to user mobiles** **Notice a bus-arriving event**	Bluetooth beacon
Camera surveillance	Camera on top of bus stop taking photos every certain interval
Lighting in remote area	LED light with infrared sensor
Provide static transit information as a backup	Paper schedule Bus route map locating all bus stops Transit assistance hotline Cab hotline
Support money change	Change machines at major bus stops

2.3.3 User Interface

Figure 4 illustrates three ways a user can access transit data: a. Website, b. Phone, and c. Smartphone. Transit data gathered by the trdansit center will be made available on the internet and to the phone service provider. Users can check schedules and other information via the transit website, hotline / text messages, and Smartphone apps. Users can also download real-time transit data from a bus stop through Bluetooth. This provides an alternative way of perceiving information displayed at the bus stop. By translating the text to voice on their Smartphone, visually impaired people will be able to ‘see’ the display at a bus stop and get notified when and which bus is arriving. A set of desired functionalities and proposed infrastructures are summarized in Table 6.

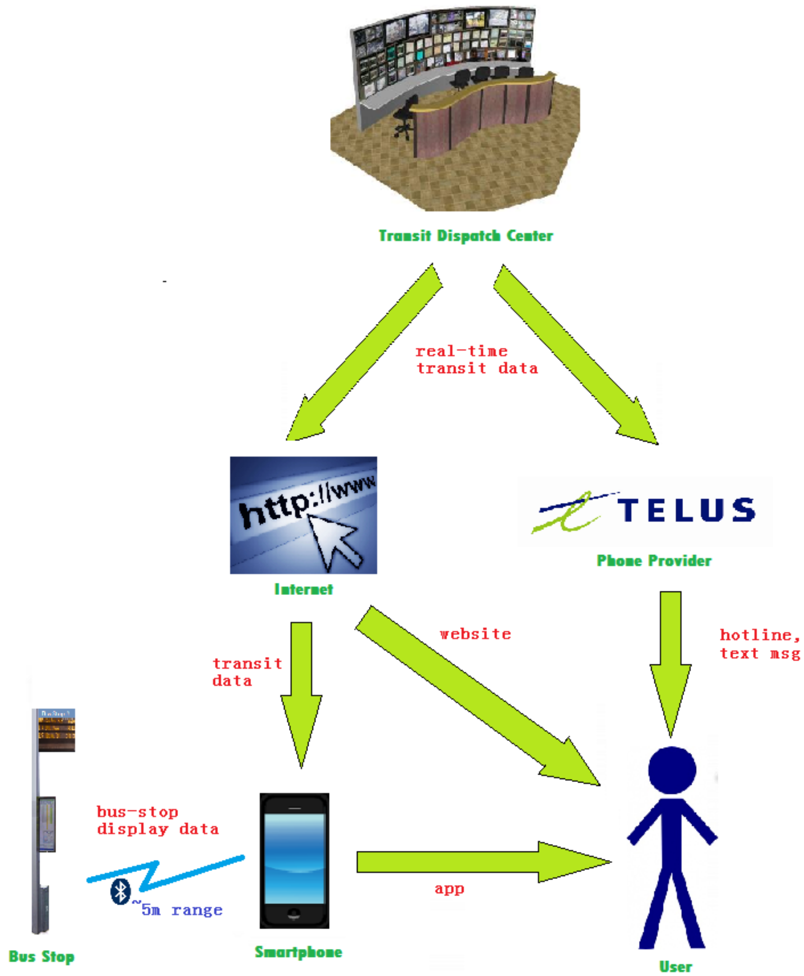

Figure 4: User interface

Table 6: Portable user interface

Desired Functionality	Proposed Platform
Real-time passenger information	Smartphone Website Phone service provider
Real-time map with bus flow and bus stops	Smartphone Website
Real-time trip planner	Google trip planner
Bus arriving alarm	Smartphone
Multilanguage support	Smartphone

Chapter 3 Textbook Review

Part two of the textbook focused on the analysis phase. This phase focused on answering who will be using the system, what the purposes of the system are and where and when it will be used. These answers will be compiled into a system proposal for management who decides the fate of the project.

The first step the analysis phase is requirements determination. This involves determining a high level explanation of business requirements and putting them into a more precise requirement list. A requirement is a statement of what a system must do or needs. Specifically, business requirements describe the "what of the system" while system requirements describe the how it will be implemented. Next, the requirements must look at functionality. This breaks down into functional and non-functional requirements. Functional requirements relate directly to the process the system must perform or information it must contain. The non-functional cover behavioural properties, performance and usability, of the system.

Chapter 3 described five techniques to elicit the requirements – interviews, joint application development (JAD), questionnaire, document analysis and observation. First, the interview process involves selecting interviewees, designing interview questions, preparing for the interview, conducting the interview, and post-interview follow up. Next, JAD allows project team, users and management to work together to identify system requirements. A questionnaire will be used when information and opinions are required from a large number of people. In Document analysis, the team reviews existing documents and examines the system. Finally, observation is performed. It means watching processes being performed and getting the reality of the situation by an analyst.

In order to think critically about the system, two techniques are used – problem analysis and root cause analysis. These techniques help the team understand the problems and issues in system that need to be fixed. The most popular analysis strategies are duration analysis, activity-based costing and informal benchmarking. They show the group the areas that could be redesigned. Commonly used root cause analysis methods are outcome analysis, technology analysis and activity elimination. This technique helps the group think about the business processes in alternative ways.

Once all the requirements are reviewed, the project team and move to use case analysis. Use case analysis is used to explain and document interaction between user and system. The use cases also help fully understand the necessary steps involved in the system. By performing this analysis, the team is lead to more focused functional requirements. A use case contains all the information required to create one part of a process model and must be expressed simply. One use case requires a name, number, importance rank, brief description, primary actor, trigger(s), preconditions, post conditions, major inputs/outputs and list of major steps. An option for the group is to create an event response list which identifies the significant events. After a used case is completed, the functional requirements can be expanded or derived.

The creation of a used case takes four steps. The initial step is identifying the trigger event and primary actor. Next, a list of major steps (from input to output) must be identified. For each step, the specific inputs/outputs need be listed. Finally, users will role-play to verify the use case was correctly written.

The next phase in the overall analysis is process modelling which describes the business processes. Business properties are the activities that people do. This is only developed for as-is and/or to-be systems. The process model comes in the form of a data flow diagram (DFD). It uses four symbols – processes, data flows, data stores and external entities. A process is an activity that does something. Each process must have the minimum of 1 input and 1 output. A data flow is a piece of data or object that has a name, description and starts at the beginning or end of a process. A data store is a manual or computer file that has a number, name and minimum of 1 input data flow and 1 output data flow. Finally, an external entity is a person, organization or system outside project and has a name and description.

Every set of DFDs begin with a context diagram, level 0 DFD. Afterwards, it has several level 1 DFDs, some level 2 DFDs and some higher levels. The elements of higher order levels must appear on lower levels or the model is not balanced.

Data flow diagrams are designed using the use cases. A team must first create a context diagram that displays the external entities and data flows. Once the context diagram is finished, DFD fragments are created for each use case. They demo how each use case exchanges data flows with external entities and data stores. After the fragment lists are completed organized into level 0 DFDs. Next, the team uses the steps within each use case to develop level 1 DFDs. Lastly, the sets of DFDS must be validated to ensure completeness and correctness. While designing DFDs, iteration occurs and is very important to ensure clarity.

The final step of the analysis phase is data modeling. A data model describes data that moves through the business processes in an organization and is a formal way of representing the data used and created by a business. The model presents logical data organization without revealing how the data is stored, designed or manipulated. This allows analysts to focus on business not the technical facts. The most common data model is the entity relationship diagram (ERD). The ERD has 3 basic elements. First an entity is the basic building block. It can be a person, place or thing where data is collected from. Next is an attribute. This is the info captured about the entity and uniquely identifies an instance of the entity. Finally, the third part is the relationship which conveys associations between entities. The relationships must have parent to child instances ratio and a child cannot exist without a parent.

The steps involved in building an ERD are: 1) identify entities, 2) assign correct attributes to entities and 3) draw relationships among entities. There are three types of entities – independent, dependent or intersection. Independent entities are those where one or more attributes are used to identify an instance. Dependent entities rely on attributes in other entities. Intersection entities capture the relationship between entities.

In order to validate the ERD, a technique called normalization is used. It is a process where a series of rules are applied to the logical data model to see how well it is formed. A logical data model can be classified into three categories. The first normal form (1NF) means the model does not contain any repeating attributes. The second normal form (2NF) requires that all entities are in 1NF and contain only attributes that are dependent on the entire identifier. The third normal form occurs when model is in 1NF and 2NF and no resulting attributes are dependent on non-identifier attributes. For each error, new entities should be added to prevent the violation. As well, the ERD needs to be balanced by ensuring all entities and attributes correspond to data stores and data flows.

In part 3 of the textbook, the design phase selects how the system will operate. These system specification deliverables are given to the programming team for implementation. At the end of this phase, the team reviews the feasibility analysis and project plan and the project sponsor and or approval committee re-examines the continuation of the project.

The first part of the design phase is the transition into the design. This involves designing a blueprint for how the new system will be developed. The blueprint contains the steps that lead the team through planning how to construct the system. The primary inputs for the design activities are the requirements. From the design phase, system specification is the main deliverable. It includes models, architecture design, hardware and software specifications, interface design, interface design, data storage design and program design.

When in the design phase, a team must consider three approaches. First option is developing a custom application in-house. This allows flexibility and creativity for solving business problems and builds knowledge in the group. The downside to an in-house design is time, man power and cost. Second option is buying a packaged system and customizing it. This permits more time efficiency as the product is already tested and built. Installation time is reduced and workaround time can be added for customization. On the flip side, purchasing time is never certain. The final option is relying on an external source. This option is quite costly as one has to pay externally and leaves the system in another's hands. Outsourcing means more contracts and risk of confidential information. Not to mention, the team potentially could lose control over future development. Each approach must be discussed and weighted amongst the team members. All areas must be examined and see which is most suitable to the team's current situation.

A significant component of the design phase is the architecture design. This describes the hardware, software and network environment of the system. It is developed mainly from the non-functional requirements. Operational requirements outline the operating environment(s) and how they can change over time. Performance requirements look at performance issues like system speed, capacity and availability. Security requirements try to prevent disruption and data loss in the information system. Cultural and political requirements are based on the country where the system will be used. From the architecture design, the main deliverable is the hardware and software specification. This is an overview of what hardware and software are required to support the application. The document first lists hardware needed to support the future system and later in detail the hardware is described. Next, the software for each component is described with associated costs. In large companies, the project team works together with the purchasing department.

The following part of the design phase is the design of the user interface. A user interface is the part of the system where users interact. It may include screen displays, screens and forms that capture data and system reports. These are the first element of the interface design. The design needs to alert the user of content and context and need to be aesthetically pleasing. Ideally, the interface should support all types of users. Consistency is a key element for navigation, terminology and layout. As well, the design should minimize user input. The design process involves developing scenarios of common user patterns, designing interface structure, testing structure with scenarios, defining interface standards, prototyping individual interfaces and conducting an interface evaluation. A very important part of the user interface is the navigation design. The main goal is to make it as simple as possible. The most common approach is the use of menus. Another component is the design of the input needs. They must easily capture accurate information for the system. The input needs cover input screens and all preprinted forms. Finally, the output design needs to accurately present information to users so they easily understand it. The output design involves creating the screen and reports in selected media.

Another activity of the design phase is the program design. This involves designing programs that perform the system`s application logic. The instructions and guidelines for these programs must be clear so programmers are able to accurately translate the requirements to a program. Structure charts are used by the design team to help correctly convey their desires. The chart shows all the functional components that need to be included at a high level. It is arranged to show the hierarchy of the program. The structure makes use of lines, loops, arrows, diamonds and modules. These elements convey the order and paths of the system. The modules can be arranged into transaction structures. These contain a control module that calls subordinates that perform independent tasks. Sometimes, the transform structure converts an input into an output.

A structure chart takes four steps. First, the top-level modules need to be identified and decomposed into lower levels. Next, control connections among the modules are added to show modules call subordinates. Afterwards, couples are incorporated to reveal the information modules pass among themselves. Lastly, the chart is reviewed and revised until it is done. It is important to remember to build the modules with high cohesion to limit a module to one function and the modules should be loosely coupled. As well, the charts should have several control modules, but few subordinates.

The final step in program design is program specification. The program specification gives more instructions about coding the modules. It contains components that communicate basic module information, inputs and outputs, special programmer instructions and pseudocode. Specifically, pseudocode communicates the code written with the use of programming structures and generic language and is written for the programmer.

The last activity in the design phase is the data storage design. The data storage design describes the data storage formats. Two basic types are files and databases. Files are electronic data lists optimized to perform a specific transaction. There are 5 types of files: master, look-up, transaction, audit and history. A database is a collection of related information groups and a database management system is software that builds and controls these databases. There are 4 types of databases: legacy, relational, object and multidimensional. The design of the data storage is based on the application's data and the type of system. In addition, the project team must look at existing and future technologies. Once a format is selected the entity relationship diagrams must be transfers from logical to physical. The physical ERDs explain how data will be stored and will contain metadata to describe the data model components. As well, the model will show design decisions about the physical implementation. After the data storage is designed it should be optimized. Specifically, relational databases can be optimized for two dimensions; storage efficiency and access speed. Normalization can be applied the logical data model to determine the efficiency of the storage. Denormalizaion can be used to improve speed. This involves reduces the number of joins that must be performed in a query. It is best used when data is regularly accessed and seldomly updated. Three areas where denomalization can be applied are loop-up tables, entities that share 1:1 relationships and entities that share too many relationships. Another way to speed up the system is to add indexes to clusters which point directly to record that matched a query. Finally, the system speed will improve if the correct hardware is purchased to support the data.

Conclusion

The “Connec4” - Smart Bus System project is initiated by four undergraduates from the Department of Electrical and Computer Engineering at the University of Victoria (UVic) in May 2012, in response to course ELEC 399 Design Project I at UVic.

The current transit system in Victoria has not kept pace with more modernized systems where real-time transit scheduling and traffic data are accessible to the general public. The project goal is to explore ideas of integrating the Victoria Regional Transit System with appropriate communication technologies and to develop a corresponding Smartphone app to enhance transit user experience in Victoria.

During the past month, team meetings were held every week and progress was reported during weekly supervisor meetings. Background and market research, product definition, project proposal, and alternative analysis were completed. The project website was launched and meeting requests were emailed to BC Transit and CanAssist. Overall, the team was able to follow the project plan in a timely manner.

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[4] S. Ezell, "The Intelligent Transportation System," The Information Technology & Innovation Foundation (ITIF), Washington, DC, 2010.

ELEC/CENG 399 Design Project I Progress Report II Evaluation Form

To be filled by students:
Project title:_______ Design a Smart Bus System**_______________**
Group #:_____________________8_________________________
Group members: Xiaoya Guo, Emily Huang, Benson Hung, Lara Juras
Supervisor(s): Dr. Fayez Gebali, Dr. Kin Fun Li, Dr. Michael McGuire
To be filled by the supervisor(s):
Progress report distributed to the supervisors for grading: Friday, July 6, 2012
Please complete the progress report grading by: **Monday, July 23, 2012**
Please refer to the rubric for grading.

1. [10%]Overall presentation:___________
    a. [3%]Table of contents are present according to the sample report attached;
    b. [3%]Citations are properly used;
    c. [4%]Conclusion is written in a clear professional technical language;
2. [10%]Chapter 1, Project Proposal :_________
    a. [10%]proposal revised according to the feedback from the supervisor(s)
3. [60%]Chapter 2, Progress Review:___________
    a. [20%] This chapter is written in a clear professional technical language;
    b. [20%] Milestones/Deadlines described in Chapter 1 are met in timely fashion;
    c. [20%] Overall progress is satisfactory;

Subtotal: ____________________**/80**
To be filled by the instructor:

4. [20%]Chapter 3 Textbook Review:_________
    a. [10%]Write the textbook review in a clear professional technical language;
    b. [10%]Meet minimum page requirement (2 pages).

Total: ____________/100

Comments by the supervisor: