Design and Development of a New Wireless Cell Site for Powertel: A Multimedia Case Study

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Abstract

The Laboratory for Innovative Technology and Engineering Education (LITEE) at Auburn University develops multimedia case studies that bring real-world issues into classrooms. These case studies are currently being used at different universities in order to show the students the integration of business and engineering theory and practice. This paper illustrates a case study they developed in partnership with Powertel (now called as T-Mobile), a wireless service provider.

In March of 2001, Powertel began a new rate plan to attract customers. The response to the new rate plan resulted in 40% growth in network traffic in a month. A particular area of interest to Powertel was the intersection of Interstate 459 and Highway 280 in Birmingham, AL. This intersection, one of the most congested areas in Birmingham, had constant traffic jams. This intersection experienced more dropped calls and busy signals than was acceptable to Powertel's customers, and something had to be done.

The potential cost of building a cell site ranged anywhere from $150,000 to $1 million. The RF engineers analyzed the problem and chose two possible solutions: add a new site on the Summit, or expand the existing site on the rooftop of the Sheraton, which was right beside the intersection. The Summit site provided higher amount of coverage, but did not allow for reuse of frequency in nearby cell sites. The Sheraton site provided a limited amount of coverage, but allowed the frequency to be reused in a nearby cell site. The managers and engineers had to decide the best option and implement it within a short time so that customers could be served better.

A multimedia case study was developed based on this problem. It was administered in a Business-Engineering-Technology program course and an Information Technology course at Auburn University. The perception of the students on the ability of this case study to teach topics in wireless technologies was excellent and the results are provided in the paper.

Introduction

Contemporary engineering design and industrial practice has undergone a drastic change in this information age where the machinery, processes, control systems, and services are information technology-driven. We use the term information technology (IT) to refer to any use of machine technology that is controlled by or uses information in some important way.

Information technologies are a combination of hardware, software, and telecommunications networks that people build and use to collect, create, and distribute data. For example, one type of information technology is a programmable robot on the shop floor of a manufacturing firm that receives component specifications and operational instructions from computer-based databases and expert systems. Another example would be a computer-controlled drill press combined with other shop floor equipment in such a way that a person could monitor and control each piece of equipment from a separate, possibly remote sets of computers (Jessup and Valachich, 1999).

Future innovations are expected to increasingly exploit synergies between information technologies and engineering disciplines (Suh, 2000). The new fundamentals of engineering include information technology, which will be embedded in virtually every product and process in the future (Wulf, 1998). In order to exploit the synergies, design of products, systems, and services require teams that can integrate information technologies with traditional engineering areas such as fluid mechanics, thermal sciences, materials science, manufacturing technologies, and precision design. In addition, more than 1.3 million new programmers, engineers, systems analysts, and computer scientists will be required between 1996 to 2006 to meet the industry's information technology demands according to a report from the U.S. Commerce Department's Office of Technology (1998). The need to use information technologies to creatively improve undergraduate education is further stressed by the Carnegie Foundation for the Advancement of Teaching (Fortenberry, 2000).

How has the education establishment reacted to the need for educating engineering students for the information age? The National Science Board states that the number of science and engineering students is dwindling and the shortage of technically skilled workers is very high (National Science Board, 2000). U.S. universities lose 40 percent of freshmen students admitted to engineering programs by the end of their sophomore year and employers chide schools for not providing the skills needed (Prados and Proctor, 2000). These observations show that the education establishment is not doing an adequate job of educating the engineering students for the information age. This in our opinion is because the appropriate educational materials that bridge the gap between theory and practice are not available to the educators.

During the past few years, we have created case studies in partnership with industries that combine both engineering and business issues, thus simulating a real-world decision making environment in the classrooms. When we implemented these case studies in classrooms, students responded favorably and indicated the benefits of connecting theory to practice and adopting the persona of a professional problem solver and engineer through the use of case studies. The evaluators of the project state that the students' efforts lend credence to the notion that engagement in case studies enhances problem solving and higher cognitive skills.

Given the success of case studies in achieving the objectives, we decided to develop a case study that shows the use of information technologies in engineering. Therefore, we contacted a cell phone company, Powertel (now part of T-Mobile) and obtained cooperation from the engineering managers in developing the case study. This paper describes the case study and provides details from an evaluation of the use of the case study in classrooms. It concludes by showing how developing such case studies are helpful in showing the impact of information technology in engineering.

Powertel Case Study

The case study centers around the response to a new rate plan announced by Powertel marketing: 3600 minutes for $40 per month. Network traffic grew 40% within the first month. By May 2001 this growth put a strain on Powertel's existing network structure. The amount of dropped calls and busy signals increased dramatically. If Powertel was to keep its new customers, Harold Gwin, Powertel's Vice President for Operations, had to act quickly. The success of the company was critical to Harold and other employees who pioneered Powertel to its lucrative position. The performance of the company's stock was essential for both corporate and personal livelihoods.

A particular area of interest to Powertel was the intersection of Interstate 459 and Highway 280 in Birmingham, AL. This intersection, one of the most congested areas in Birmingham, had constant traffic jams. Of course with the gridlock, came thousands of bored people with cell phones. When people got stuck in traffic, many of them reached for their cell phones. This intersection experienced more dropped calls and busy signals than was acceptable to Powertel's customers, and something had to be done.

Harold called Andrew Harman, Radio Frequency Engineering Manager for the Alabama – Mississippi area, and asked his opinion on new possible cell site locations. Andrew was in charge of making sure the network runs efficiently and effectively, as well as deciding where to put cell towers for optimal performance.

After analyzing the data gathered from the computers monitoring the intersection of Interstate 459 and Highway 280, Andrew and one of his top Senior RF Engineers, John Favretto, discussed possible solutions to the network problem. The two options considered were: adding a new cell tower on top of Summit, a hill near the intersection, and adding cell sites on the top of the Sheraton hotel. The potential cost of building a cell site ranged anywhere from $150,000 to $1 million. Cell tower construction accounted for over 80% of Powertel's total costs. Andrew Harman was assigned the task of picking the cell site in Birmingham taking into account engineering and business issues associated with cell site construction.

The advantages of putting an additional site on the Summit were:

- It contains the tower that the antennas can be mounted on
- The site can be managed, governed, and manipulated as required by the owner
- The coverage area of the site will be large, compared to the alternative site at the Sheraton hotel.

The disadvantages of putting an additional site on the Summit are:

- The increased coverage of the Summit due to its location on top of a hill restricts frequency reuse.
- Remote hilltop location increases service costs due to maintenance or other problems that

may arise.

- Outdoor location exposes equipment to weather, which will increase maintenance costs.

The advantages of putting an additional site on the Sheraton were:

- The site does not need much of the preparation such as laying a foundation and fixing the equipment to the foundation.
- It does not require a place for the tower to be hoisted
- All the equipment is protected from natural hazards (such as rain, snow, direct sunlight, etc.)
- There is no need to build a different room for the equipment
- It does not require much care when compared to the sites such as the Summit.

The disadvantages of putting an additional site on the Sheraton were:

- The Sheraton site has a smaller coverage area; therefore, additional towers may have to be built.
- Additional studies will have to be conducted to assess whether the Sheraton rooftop will support the additional weight of new equipment.
- Powertel will have to renegotiate fees to rent additional space atop the hotel.

Data Provided to Students

In order to analyze the case study, the students were provided data on: the potential coverage area by implementing either of the options, ability to reuse frequencies given the limited amount of frequencies assigned to each cell company, the process of building the new sites including blue prints, utilization charts up to May 2001, potential utilization by implementing either of the two options, percent utilization and grade of service for each option. In addition, they were provided competency materials on wireless technologies and references to internet sites. Videos and charts showing the construction of cell sites were also provided. The tasks involved in the project management were also described. Through this process, the students were provided the same information as that used by the engineers and managers in making the site selection decision.

A CD-ROM was developed that included interviews with the engineers and managers of Powertel, videos of cell site construction, photographs of the sites, charts showing utilization data, and videos showing the construction process of cell sites.

Assignment to Students

The students were divided into four groups. The first two groups defended the decision of building site either at the Sheraton or the Summit. The third group made a decision regarding the design options and the future requirements of Powertel. The fourth group made a final decision as a management team. The tasks of each group were:

- Team A: Defend the decision to build the cell site at the Summit and develop a plan including drawings to support your decision.
- Team B: Defend the decision to build the cell site on the top of the Sheraton and develop a plan including drawings to support your decision.
- Team C: As consultants, find out design options through which future demands for service could be fulfilled quickly so that customers will remain with Powertel. Develop a plan including drawings to illustrate your design option.
- Team D: As management team, decide which option is best: the green field or top of the Sheraton given the business, technical, engineering, and legal issues. Develop a plan to implement your recommendation.

Learning Objectives

In the words of Harold, "It's a classical engineering/marketing/economic problem." For engineering students, this case is helpful to enhance knowledge about frequency reuse, CAD drawings, performance graphs of cell sites, honey comb models of frequency reuse, propagation of radio frequencies, and cell coverage of frequency. At the same time business students can use their experience to weigh issues such as marketing; economic issues such as the cost involved in building the cell site versus the cost of losing customer goodwill.

The learning objectives are:

- Enhance knowledge about frequency reuse
- Learn about how to read CAD drawings
- Interpret performance graphs of cell sites
- Differentiate between theoretical and practical honey comb models of frequency reuse
- Learn about propagation of radio frequencies
- Understand how marketing strategies impact engineering and technical decisions
- Learn about economic issues such as the cost involved in building the cell site versus the cost of losing customer goodwill by dropping calls.

Administration in Classrooms

This case study has been administered in business and engineering classrooms at Auburn University. Questionnaires were provided to students to obtain feedback on implementation of the case studies.

Students' Evaluations of the Powertel Case Study

The evaluation results for two courses, BUSI/ENGR 3520 and MNGT 4850, in which the Powertel case study was used at Auburn University, are shown herein. In the BUSI/ENGR 3520 course, the Powertel case study was used to teach students concepts of engineering design and management, whereas in the MNGT 4580 course, the case study was used to teach students concepts of resource allocation and strategic management. The utilization of the case study to accomplish the aforementioned tasks took place during the Spring 2003 semester. In order to discern their reactions to the case study, the students were asked to complete a 72-item questionnaire. Presented herein are the students' (N = 36) reactions to the case study.

Since there were a total of 72 questionnaire items, it was important to identify whether some of the items could be combined together to represent a particular construct. Based on past literature (Hingorani & Sankar, 1998; Marghitu, Sankar, & Raju, 2003; Mbarika, Sankar, Raju, & Raymond, 2001), we focused on five constructs of the Learning-Driven Factor, which included 26 of the 72 questionnaire items. The mapping of the constructs and the questionnaire items are shown in Table 1. Because no single item is a perfect measure of a concept, we employed the most widely used measure, Cronbach's Coefficient Alpha, to assess the consistency of the scale used in this study (Hair, Anderson, Tatham, & Black, 1998).

Table 1: Mapping of Constructs and Questionnaire Items for Evaluation I

Constructs	Items
Higher-Order Cognitive Skills Improvement (9 items)	• I improved my ability to identify issues related to the wireless industry • I improved my ability to identify issues related to cost/benefit concepts • I improved my ability to integrate issues related to the wireless industry • I improved my ability to critically evaluate wireless alternatives • I improved my ability to critically evaluate cost/benefit alternatives • I became more confident in expressing my ideas • I learned to interrelate important topics and ideas • My decision-making skills improved • My problem-solving skills improved
Self-Reported Learning (7 items)	• I improved my understanding of basic wireless and cost/benefit concepts • I learned new concepts related to the wireless industry • I learned to identify central issues related to the wireless industry • I learned to identify central issues related to cost/benefit concepts • I found connection between wireless concepts discussed and the case study • I found connection between cost/benefit concepts discussed and the case study • I identified various alternatives to the problem
Learned from Others (2 items)	• I learned to value my colleagues' points of view • I learned from other colleagues during the session
Learning Interest (5 items)	• I discussed topics related to the wireless industry outside of class • I did additional reading on wireless topics • I did additional reading on cost/benefit topics • I did some thinking for myself about wireless issues • *I did some thinking for myself about cost/benefit issues*[1]
Challenging (4 items)	• The case study was successful at bringing real-life problems to the session • The case study was challenging • The case study was helpful in learning difficult concepts • The case study was helpful in transferring theory to practice

Cronbach Alpha values were computed for the five constructs listed in Table 1. Cronbach Alpha values range from 0 to 1 and depict the degree to which the items are indicative of the latent construct. Treacy (1985) states that a value of 0.70 and higher is an acceptable level of Cronbach's Coefficient Alpha. The Cronbach indices of reliability for all the constructs used in this study, except for the *Learned from Others* construct, are at or above the acceptable level

[1] In order to improve the internal inconsistency of the construct, this item was dropped from the study and not included in construct mean, standard deviation, or Cronbach alpha value calculation

(see Table 2). That is to say all the items, except those measuring *Learned from Others*, satisfactorily indicate their respective latent constructs.

Table 2 Construct Cronbach Alpha Values

Higher-Order Cognitive Skills Improvement (9 items)	*Self-Reported Learning* (7 items)	*Learned from Others* (2 items)	*Learning Interest* (4 items)	*Challenging* (4 items)
.89	.89	.67	.70	.88

Table 3 Construct Means and Standard Deviations

Higher-Order Cognitive Skills Improvement (n = 36)	*Self-Reported Learning* (n = 36)	*Learned from Others* (n = 36)	*Learning Interest* (n = 32)	*Challenging* (n = 36)
3.94 (.08)	3.96 (.03)	3.94 (.10)	3.8 (.23)	3.88 (.22)

The means and standard deviations of the five constructs, as reported in Table 3, represent the students' reactions to the Powertel Case Study. Given that the scores fall on a 5-point continuum with a score of 5 representing the highest possible response, the means are on the positive side of the continuum for all five constructs. In fact, all five constructs received mean ratings of 3.8 or above. These results appear to indicate that the students had a favorable reaction to the Powertel Case Study. We discuss the results for each construct below.

The students perceived an improvement in their higher level cognitive skills as indicated by the mean of 3.94. Supporting this quantitative result were some comments from the students:

- Introduced a real life problem where the alternatives were evaluated based on cost/benefit.
- Technology brought into the class, the thinking is stimulated.
- Familiarized us with wireless technology
- This case study was directly applicable to real-world decisions that must be made in the work place.

They perceived high levels of self-reported learning (mean = 3.96), learning from others (mean = 3.94) and stimulation of learning interest (mean = 3.8). Supporting this quantitative result were some comments from the students:

- I learned a lot about wireless technologies and the cost factors behind it.
- Current situation, very interesting, not yet solved problem.
- I enjoyed listening to other people's ideas before making any decision.
- It was interesting. It was a different concept and I really enjoyed learning about it.

The students perceived this assignment to be challenging (mean = 3.88). Supporting it were the following student comments:

- Strong real world application.
- The objectives that were presented were clearly stated and the solutions to the problems could be found in the CD and book.
- Current situation, very interesting, not yet solved problem

- Challenging!!

Conclusions

The results and findings show that the development and implementation of the Powertel case study in engineering classrooms was successful. This success indicates the urgent need to develop other case studies that describe decision situations on contemporary topics:

- Hybrid vehicles (gas and electric)
- Use of nanotechnology in products
- Bio-medical engineering and its use in medicine
- Outsourcing of engineering functions to other countries using information technology
- Deployment of space vehicles on moon and mars
- Intelligent weapon systems and its use in modern warfare
- Use of smart objects in day-to-day uses (such as watches, clothes, and homes)
- Need to develop case studies in other langauges

In addition, a national digital library that contains the information-technology oriented case studies would be of interest and use to engineering educators and students. That would make it possible for educators to tap into a rich source of real-world problems when explaining complex engineering concepts and theories in the classroom.

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