Prototype of a New Engineering Masters Project Model: Working with Marketing and Software Faculties to Commercially Kickstart University Research

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Abstract: We describe a Master of Engineering (500-level) project modelled on the real-world arrangement where engineers work with marketing and software groups to prepare a product for commercialisation. A 4-member software team to develop and test embedded firmware and support applications on a mobile platform was provided through a final-year undergraduate software-engineering project course based outside the engineering school, in a separate faculty. A marketing team consisting of interns prepared logos, product names, and advertising materials, with input from a creative 200-level class. This team also considered possible exit strategies based on analysis of the market size and activity. This marketing effort was organised through the management communications group in the magagement school. The masters student acts as project manager and it is their remit to guide the product towards release on the crowd-sourced venture-capital site `kickstarter.com`. A small but original product idea is required to provide a viable vehicle for the project. Financial commitment to manufacture, even on a small scale, represents a novel outcome for a university project.

Keywords: Continuing education, Electronics engineering education, Venture capital, Interdisciplinary collaboration, Project management, User interfaces, Digital command and control (DCC), Microcomputer applications

1 INTRODUCTION

Engineers are expected to have team skills. In modern product development groups they typically work with programmers and marketing personnel to develop a manufacturable prototype in parallel with documentation, marketing materials, and marketing strategies. In the "Silicon Valley" model, engineers are also stockholders and may be involved with business decisions such as IP protection approaches and potential corporate exit strategies. On the other hand, undergraduate programs typically emphasize technical learning, although modern accreditation programs demand an amount of teamwork and management skills. Much of the practical detail of product development is left to be picked up "on the job", possibly through industrial placements such as those integrated into the degree structure of Antipodean universities.

Our thesis is that we ought to be able to provide the real-world learning through a Masters program. The program model reported in this manuscript is a compact version of what really happens in our industry. We address the questions "How might a small version of what happens in industry be arranged at a university?" and "How can such a program be assessed?"

2 THE MODEL

For the purposes of the experiment, the masters student, the second author of this manuscript, is regarded as the project manager (PM). In this particular instance he is also the "chief hardware engineer". The supervisor has the responsibility of establishing liason with colleagues in computer science or software engineering, and with marketing or management communications, and generally providing "the environment".

To fit viably in the time available, the project must either have been proven feasible beforehand, say through the existence of a prototype that demonstrates the technology, or be of a level of difficulty such that the hardware could be constructed in about half of the available time. A masters program to corresponds to something between 1200 to 1800 hours. By way of comparison, universities typically consider a full-time academic employee to contribute 1500–1800 hours per year once allowance is made for leave, overheads, and inefficiences.[1] The provision of a vehicle project is not as serious a demand as it might appear at first. There were several candidate projects available to the authors, including various toys, gadgets, and small appliances. Websites such as `kickstarter.com` are a fertile source of inspiration, and variations on exiting themes provide more opportunities.

For the experiment reported here, we chose a small electronic toy using a microcontroller with embedded firmware that demonstrated some novel ideas. The history and technology of this particular project, and its suitability for this experiment, is covered in section 3.

3 The Technology

The Electronic Engineering problem of transmitting both power and control data over the same pair of wires has arisen in a variety of contexts, including domstic power delivery, household automation, and remote control of small tethered tools and toys. The model railway industry provided an elegant solution for this several decades ago. It was developed by Lenz in Germany for the Märklin and Arnold companies in the 1980s. [1] The system is today known as "DCC", standing for Digital Command and Control. It was accepted as the global standard, published in February 1994 by the NMRA, and has been adopted by all major model railway manufacturers. [2] After the fashion of TCP/IP it is documented as a series of standards and recommended practices, or RPs, available from [2].

The DCC standards make no specification about the user interface (UI). A major problem impeding the acceptance of DCC in the marketplace has been the overly complex and technical format of controllers. Figure 1 epitomises the problem. The advertisement in the figure depicts a complex-looking piece of equipment that at first glance could be any instrument from an engineeing lab, rather than a consumer toy. The caption proudly displayed—"If you can use a TV remote, then you can use the Elite"—tells the potential buyer that he or she is in for a frustrating, technical experience. The adoption of DCC has been very slow, in spite of its technical elegance and universal adherence to the standards that guarantee compatibility of various suppliers' products. Browsing a high-circulation trade magazine such as [5] serves to confirm that the technical experience promised by the product in figure 1 is the norm. Interviews, conducted in 2009 in collaboration with the psychology school, discovered that in clubs where DCC is widely deployed, a small fraction of the members understood the technology, and typically provided de-facto technical support to the others.

Over a period of about two years, staff and students at our institution have solved the problems of assigning and remembering addresses, in much the same way that USB solves that problem in comparison with bus connection of IEEE488-equipped instruments, but without an upstream data channel or cooperation of the adressees, as this is not generally available on DCC systems. [2] Also, a new UI has been designed that takes advantage of the scanning technology to eliminate the need for a keypad. The new controller compares with designs of the type depicted in figure 1 as an iPhone compares to phones of early 1990s vintage: It is vastly easier to use, but in the end does the same thing, save elegantly, in accordance with accepted design principles. [4]

The hardware constructed to verify feasibility of our ideas represented a prototype for a potential product. The university declined to patent these ideas, considering the small market addressed by DCC. A processor turn and relayout of the PCB on the original design and the development of a manufacturable form factor and enclosure seemed like a suitable hardware task, perhaps a few hundred hours work. In the end, we decided to make provision for Bluetooth connectivity as well via a daughterboard. Our design, employing the new technologies that we have dubbed "iDCC", seemed like an ideal candidate for this experiment. Figure 2 shows the mock-up enclosure prepared early in the project and figure 3 depicts the view when train reprogramming is required. If two locomotives respond to a single knob, one requires reprogramming. The enclosure is inverted and the locomotive placed on a short track attached to what is normally the bottom of the controller for a few seconds while the locomotive is automatically reprogrammed.

4 The Market Space

The model train industry is a lucrative niche market worldwide. In New Zealand alone the market is estimated to consists of approximately 9000 consumers, based on exhibition attendance. Research gathered previous to this marketing teams involvement indicates that the market is vast, and ready for a user-friendly controller such as this. Ad-

[1] This count is for "billable" hours, used in calculating consultation rates. Statistics suggest the average engineering academic puts in rather more hours.

Figure 1: Full-page advertisement for a typical, mid-range DCC product taken from [3]. Of particular interest are the tag lines that carry exclamation marks.

Figure 2: Mock-up of the enclosure for presentation to branding and software groups. The end-plates are arranged to present the panel tilted forward.

ditionally, the number of competitors in the general model railway market indicates a large market.

Within the industry there are several brand giants such as Hornby/Bachmann and Märklin who dominate the industry but do not offer user-friendly controllers. It is therefore obvious that there is a gap in the market for this product to fill. Basic DCC controllers by these companies sell for around NZ$200-$400, with the more sophisticated products starting at approximately NZ$400. We note that this product offers a serious benefit to consumers because it is useable by all rather than a select few, as different from competitors' offerings. Therefore we plan to use a skimming price strategy, meaning a premium price, which will not only allow for recouping of production costs but also reflect the higher quality of this product.

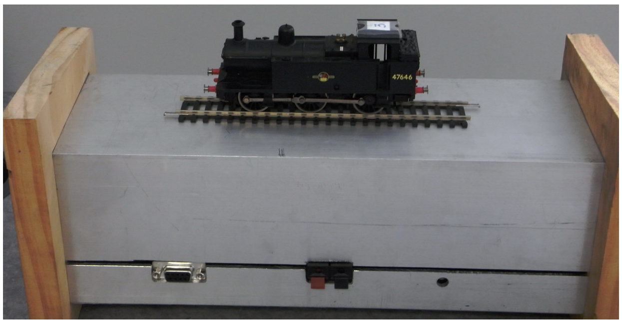

Figure 3: Bottom mock-up view showing the automatic programming track activated by inversion of the enclosure. The view also shows track, power and serial connections on the rear of the enclosure. The end-plates leave the bottom level when the enclosure is inverted on a level surface.

Digital Model Railway information dissemination and product sales occur through print magazines, enthusiast clubs and exhibitions, and increasingly through the internet. The internet presence is very strong, including enthusiast sites, dedicated toy or railway specialist online retailers, and dedicated blog and chat groups. This business model (no pun intended) means that it will be quite feasible to present iDCC via the internet: It seems model railway enthusiasts are more able to use a browser than a DCC controller.

In 2009, a web site that provides what might be called "crowd-sourced venture-capital" appeared. [6] The site was established for the purpose of enabling artists to fund exhibitions of their creative works, but was soon after described as having enabled "indie films, music, comics, journalism, video games, and food-related projects". [7] Today it has funded a number of substantial high-technology startups. For example, a Queenstown-based duo recently received US$636,767 when seeking US$150,000 for the manufacture of a device of complexity comparable to the iDCC project described here. [8] Figure 4 is a screen capture from the web offering around the time it was released. An option for us will be to present the product through a site such as this, offering early adopters the chance to buy the controller at around the construction cost in exchange for their backing, effectively pre-sale of a limited run of units.

Before the marketing team came on board, the technology embodied in this product was referred to as "iDCC",

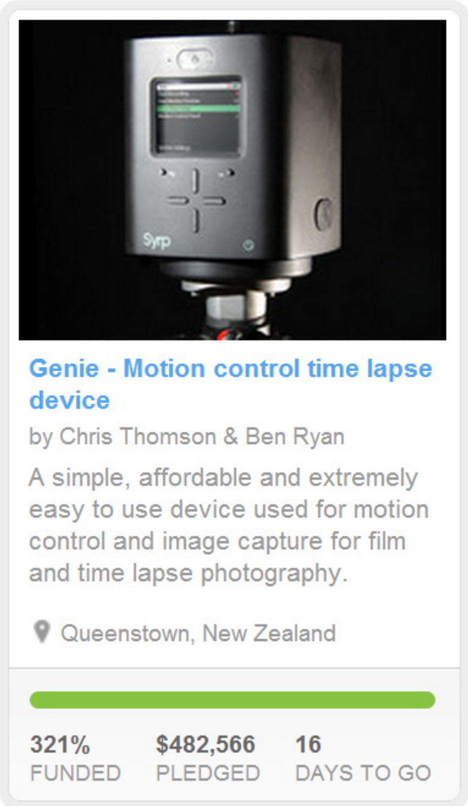

Figure 4: Screen capture from kickstarter.com depicting the "Genie – Motion control time lapse device" part way through its offering. It eventually raised 425% of its funding target.

mimicking the labelling of products such as the iMac and iPhone, invoking the "imaginative" aspect of the user interface design. A class of about 130 students of consumer behaviour were asked to suggest a name and tag line for the initial product. The name selected was "Tereina", which translates as train in the New Zealand native language of Maori. This gives the product a distinctly New Zealand feel, an advantage as there appears to be a large market within NZ for this product. Also, NZ is generally viewed quite favorably world wide and products made here are of an assumed-high quality. Using an associated name may transfer some of these ideas onto our product. We are aware the definition of Tereina is not common knowledge so we aim to incorporate images of trains into the logo and any advertisements to ensure consumers are aware of the nature of the product. Other suggestions included "The Fat Controller" which found favour, but only with people familiar with the Thomas stories.

A range of tag lines were suggested, including "Maximum control. Minimal complexities. The future of DCC, full steam ahead", "No complicated addresses. No complicated programming, Just trains", "Optimal control. Zero difficulty", "No keypad. No programming. No hassle!", "Play now, think later", "The future of model train controllers", etc. The concepts of simplicity, mastery, fun, and the future all recurred.

5 Firmware

The University offers a course entitled "Software Engineering Project", COMP314. Students are placed in teams of 4 and assigned to projects. A good fraction of the projects are provided through industry partners. Around 14 weeks are available for work on the project, with something like 200 hours of work expected from each student, but this includes overhead, planning, progress reporting, etc. The Tereina embedded firmware was developed by one team of four computer science students. They reported working on the project for at least six hours per week for 11 weeks. Many of these hours were spent planning and pair/team programming and not individually so it is hard to estimate the actual amount of time spent writing code.

Some existing code was available at the beginning of the project from the proof-of-concept prototype. However, much of this code needed to be rewritten and/or refactored as it was not very well designed and was "hacked together" to get the proof-of-concept to work.

The firmware will feature all the basic train movement functions including an emergency stop function and the ability to turns the lights on and off. Also included will be functions to automatically scan for DCC-capable trains on the track and the ability to turn the controller itself upside down to reprogram a train to a new, unique address. Bluetooth and serial connections will be included to allow connections to computers to control the trains via other software or possibly to allow the ability to create a mobile application that can interface with the controller.

As the need for reliability of the software was identified, unit tests were used extensively to verify the ability of the functions offered. This along with the pair/team programming was used to try to guarantee an extremely low likelihood of failure as the software cannot in general be updated after it is shipped out to paying customers.

At time of writing, the lights function is not working correctly and we did not get a chance to set up bluetooth properly as the new hardware was not available. We have approached the very limit of the program memory that the microchip could hold. There is only enough room to write basic serial sending code for when the controller discovers a train; the original microcontroller did not have enough program space to continue on with serial to handle instructions and send more information back to a host computer. The new processor is not yet available.

6 Prognosis

At time of writing it is not clear if the project will reach release and offer "commitment to manufacture". However, it is clear already that it has been a success. All of the elements that we intended to include as part of duplicating the industrial process of managing a project have started.

Close to the time at which this manuscript is included in the conference digest the project will reach a milestone. That milestone corresponds to the software team completing their course, and signing off the firmware. It may be that the firmware achieves most or all of its goals, and the prototype is deemed to have sufficient features to warrant going to market. Conversely, the firmware may not be debugged sufficiently to justify risking venture capital. If the latter is the case, the project will be treated as it would in industry. There is a point in every project at which it makes no sense to commit further resources, and the project halts, and staff are reassigned. The manager reviews the project. Perhaps the project should be scrapped completely, perhaps it should be mothballed until new technology, reduced costs, or increased market size make it appealing to revive the work. Perhaps the PM decides that the software is close to completion and he can finish it. In any case, he will take that decision and write up its justification.

Go ahead or not, the parameters of the offering must next be set. A price must be decided. Using `kickstarter.com` entails setting a scale. The PM needs to nominate the number of units to be offered, and what level of pledge is required to trigger committment. A small offering is the safest, say offering 20 units, and requiring a pledge for ten before becomming committed. To an extent, the wisdom of this decision, and following through with it, is the key assessible outcome.

7 Assessment

University structure requires that assessment occur through a submitted thesis. This thesis can take the form of a Project Manager's Report. If that report points to what amounts to a crowd-sourced venture-capital offering, so much the better. If that offering is successful, better still. Nevertheless, if the report describes an outcome that did not lead to an offering it may represent no less capable a piece of work. There is no need for such a "failure" to warrant low marks. It will be the handling of whatever happens, as reported in the submitted manuscript, that earns the student his or her grade.

It is a commonly-accepted principle in Silicon Valley that involvement in ventures, even financial failures, is the best educational credential. Perhaps one in 20 is financially successful, but the majority are educationally successful for the intimate participants. It is to be hoped that the same will be true within this educational model of a Master of Engineering.

Figure 5: Group photograph of the iDCC team, including management, programmers, and marketing.

8 Acknowledgment

A great many people had input to this project. Dr David Streader assembled the software team as part of COMP314. Dr Valentyna Melnyk guided the consumer behaviour class, MKTG251. The iDCC concept received input through undergraduate summer projects and students in ENEL417, especially Mark Jones, Refael White, and Lasa Tilakaratne. The authors wish to acknowledge the technical assistance of Pawan Shrestha and Weiqian Zhou. Commercial relevance was provided by Darren Harpur of WaikatoLink. Figure 5 shows the team.

9 Conclusion

We have presented a new framework for a masters degree project that involves wide interdisciplinary cooperation similar to that found by engineers in industry. A major outcome of the project is expected to be a presence on kickstarter.com, demanding a high level of commitment. We believe that the experience reported here is sustainable, and could be repeated at other institutions.

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