Technology Transfer: Why some Succeed and some don't

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ABSTRACT

In this paper we present several technology transfer cases both successes and failures. These cases describe transfers from research department within a large corporation to a product company, university to a large product company and university to a small product company. Based on the analysis of these cases we outline several strategies that can be used, in isolation or combined, in order to increase the probability for success.

Categories and Subject Descriptors

K.6.1 [**Management of Computing and Information Systems**]: Project and People Management–*Life cycle, Systems development*

K.6.3 [**Management of Computing and Information Systems**]: Software Management–*Software development, Software Process, Software selection*

General Terms

Management, Economics, Human Factors

Keywords

Technology Transfer, Research Collaboration, Software

1. INTRODUCTION

Technology transfer comes in many flavors and involves different parties depending on various situations. The success is dependent on several important factors, including the maturity of the technology, receiver's expectations, and commitment from receiver. Moreover, successful technology transfer is also a matter of timing. The research must be in a mature enough state and the results from a transferer must fit in the receiver's culture and business situation.

There are many drivers that motivate technology transfer. We define technology suited for transfer to be in the form of competence, methods, tools, prototypes and ready-made products. The reasons lie in the receivers' interests. Examples of reasons that may generate the necessary pull of new technology are: *replacing obsolete technology*, *increase efficiency* (improved methods, tools, cheaper components, COTS enablers), *attract customers and engineers*, and *comply with customer specific technology requirements*.

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In this paper we discuss four different actors taking part in technology transfer: the *big product development company* and its *research unit*, the *small company* (that does not have its own research unit) and the *university* (depicted in Figure 1). Naturally, these actors have different objectives, goals, and responsibilities.

A research unit of a large company has, as part of its role, objectives to leverage on university resources as much as possible. The research unit should scout what the universities are doing and capture interesting technology and facilitate transfer into the company's business units. Moreover, the research unit should perform technology development and transfer technology to the business units.

For a small company, i.e. a company without a separate research unit, the technology transfer may take other forms than within the large company. For instance, a small company might be a spin off based on successful applied research from the university.

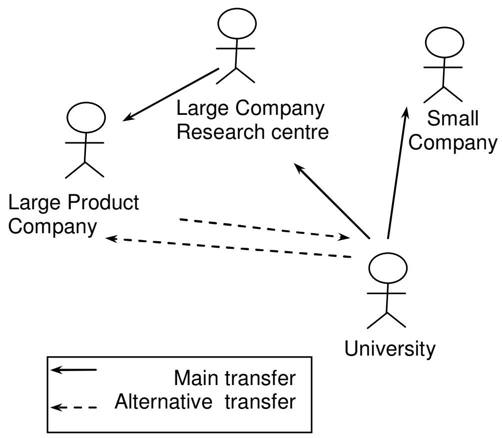

Figure 1 The different actors considered in this paper regarding technology transfer

Ideally the technology transfer from university to industry, where transfer is a result of basic research and technology development. However there are cases where industry develops technologies that influence universities, e.g. through de-facto standards. We illustrate in Figure 1 that transfer can take place from the industry to the university with a dashed arrow, indicating less frequent occurrences of transfer. The transfer paths shown in Figure 1 reflect the cases described in this paper. However, for the sake of simplicity, we have omitted several possible transfer paths, e.g. from the small companies to the universities or other companies.

An actor in our framework can, as shown in Figure 1, have the role of both transferer and receiver, e.g. a corporate research unit acts as receiver of knowledge from universities and as a transferer of knowledge to the business units.

Not only is the success of technology transfer dependent on the involved actors, but also on the technology as such. Research results are matured through different phases from unclear and ambiguous ideas through its crystallization, understanding, dissemination and utilization. Mary Shaw has identified several phases in a research life cycle ranging from basic research in which the problems are recognized and the key ideas provided to the popularization in which comes to the real transfer of the knowledge and technology [5]. Consequently, the maturity of the technology is dependent on where in its life-cycle the transfer starts. Moreover, the research tradition has ideals and follows patterns that are fundamentally different from those in industry. Research is very much related to science, and the governing objectives of sciences are to explain the world, rather than utilize it. This tradition has remained in the new research areas, even in those in which the primary goal is not to explain the world but discover or develop a new not-yet existing things. In this tradition the focus is on thoroughness and completeness: the results (either new discoveries or explanations of existing phenomena) must be explained, validated, related to other works and their boundaries must be identified.

The Software Engineering Institute at Carnegie Mellon University applies technology transfer in three main phases: (i) create – this include basic research and development of the concepts, (ii) apply - it includes applying results on the real cases in cooperation with industry and developing technology for large scale, and (iii) amplify – in this phase the results are widely disseminated and transferred to industry. Again such a process can take many years. This approach indicates that both partners should be involved in technology development, and not only in transfer.

The question is at which point the transfer shall start, at which point the industry should be involved? The process of developing a new technology often takes many years which often impose an obstacle when initiating a technology transfer to product business units. Product business unit has short-term goals and long-term goals and no one can be compromised on the price of the other. The short-term goals are related to current liquidity and profit, usually characterized by direct and intensive relation with customers. The short-term goals are usually of higher priority, and the company usually shows most interest in acquiring technology that solves the problems at hand with as little effort and risk as possible. The long-term goals are supposed to assure customers' confidence, and future successful business. Technology that addresses long-term, strategic, goals are harder to transfer since a product developing receiver tends to focus its resources on current problems and development (e.g. time-to-market).

In this paper we show several examples of technology transfer, some of them successful and some of them not. From these examples we provide some findings and conclusions as input for further discussions, research and improvements in practice.

The rest of the paper is organized as follows: Section 2 describes several successful technology transfers, and Section 3 an unsuccessful transfer. Section 4 analyzes these cases and provides certain findings. Based on our experiences we list identified transfer strategies in Section 5. Finally, section 6 concludes the paper.

2. SUCCESSFUL EXAMPLES

There are certainly many factors that affect the success of technology transfer. In this section we will present five cases as a base for discussion about success factors.

2.1 Research to large product company

Our first example is a project, Success1, executed by a research unit at a large product company.

The main objective of Success1 was to develop a working prototype that could be used to demonstrate a concept in robot automation. The project was a bit controversial from the industrial perspective since this concept had been intensively discussed over several years. Several people in the business unit did not believe in the idea while others did, as a consequence the idea never left the drawing board. Utilizing the research unit gave them the opportunity to have someone neutral outside the business unit investigate in the idea. Now, with an external unit developing a prototype, the problem of technology transfer was introduced. Already from the start of the project this was identified and planned for. During the whole year of development the research unit had weekly meetings with the business unit. On the business unit side a champion stepped forward and pushed for the concept within the business unit. However a receiving person was missing and sought after from the beginning. This was achieved by having a person in the project temporarily employed by the research unit was later employed by the business unit. That person became the "perfect" receiver of the technology. Even if this scenario was fortunate for the project and not likely to happen for every project, a receiving group was early identified and the manager of that group committed. During some intensive period of work the researchers moved their lab to the business unit to achieve a tight collaboration.

If we look at Success1 we see clearly that the request for a receiver from the beginning was the key factor of success, also contributing was the research project lead's ability to mediate a feeling of cooperation in the project.

Success factors identified from a transferer (academic or research) perspective:

- Continuous communication with the receiving party
- Demand that a receiving person is nominated early in the project

From a receiving/industrial perspective in Success1 it was the need to resolve a long time dispute over a technical concept that spurred the interest of key persons. A champion was identified early in the project and helped pulling the results into the receiving unit.

From an industrial perspective the following success factors are identified:

- Someone championing the technology
- Clear interest in the technology
- Feeling part of the transfer

Another project in the same category is one with the objective to research and develop tools and methods for improving software maintenance in industrial process control. We call the project Success2.

This project spans over several years and differs from Success1 in the sense that this was not technology for the end customer but a tool for improving internal efficiency. In the beginning the research unit worked very much as resources to the product company and not much research was conducted. Main reason for this approach was that the research unit needed to build competence and gain credibility in the field. After the first year we introduced work packages with more research content in the project and now technology transfer issues started. Until this point the work was merely on order from the product company and the transfer of developed technology not an issue.

When the project shifted to more research content a continuous updates transfer strategy was selected. We will elaborate further on transfer strategies in Section 5.

Keeping the product unit closely in the loop opened up for discussions on how to utilize and leverage on the technology presented from the research work packages. The main success factor in this project from the transferer perspective was the willingness to listen to technology customers and adopt both the research and development after their need. This flexibility and willingness to help, lead to enormous increase in credibility which in turn opened for the technology transfer.

The receivers of the technology were always encouraging and contributed to a positive working climate and this must be considered as another success factor for the transfer.

2.2 University to large product company

In this section we describe two successful technology transfers one design tool for embedded real-time systems to a product development company (Success3) and an analysis tool for complex embedded systems to another product development company (Success4).

In success3 the researchers where invited to discuss a future software architecture. In that discussion the receiver realized that the concept that the researchers proposed would solve their problem. However, a design tool supporting the concept was missing. The researchers were challenged to develop a prototype to demonstrate the concept which the researchers assumed. The first prototype was accepted by a senior specialist. However, since the tool would change the way the next generation software was to be developed there was also a strong requirement on education and support during the first projects.

In summarize, in order to deploy the tool and the methodology successfully, *tools, education* (courses, tutorials), *carriers*, and *adapters* were required.

When transferring a theory to industry, unless very simple [6], it is necessary that the theory is encapsulated in a tool, demonstrating its practical use [1].

The first version of the tool was written in a high level language which was easy to adapt to new requirements. The handling of these up-coming requirements in an efficient way is important for success in the transfer, an operation in which the carrier, described below, plays a significant role. Later on the tool was ported to a low-level language resulting in an efficient implementation.

An engineer required at least two days of training to understand sufficient basic real-time theory and associated methods to be able to work in the design of the new systems. In reality it will take an experienced engineer about a week including the training course to be productive, when using the model and methodology.

The success of this project has been mainly due to the fact that one member of the research group started to work as a consultant in the receiving organization. Regardless of how many excellent reports that are written, people are needed to carry the results [2]. Citation: "Tech transfer is a contact sport. People, not papers, transfer technology" [4].

Even if we have carriers we need early adapters at the company to take the technology into the company and its organization. These people need to be authoritative to be able to sell the new technology in the organization. There is always a healthy conservatism in all organizations. Therefore one must find people ready to invest enough time and energy to determine if or not the technology is applicable and gives an added value to the development of their products [3]. In this case this was the senior specialist.

In Success4 the technology transfers had less impact on the development team then in Success3, since the tool transferred is an analysis tool that enables analysis on an existing system. The keys to the successful transfer were that the researcher that developed the tool had previously been working in a development project and hence had a thorough understanding of the system as well as valuable network of contacts. Moreover, the main supporter of the project was a senior specialist in the company. The deployment job was done in two phases, first the tool was developed in close interaction with the senior specialist with short turn around on improvements, and second the tool was evaluated by some few persons selected by the senior specialist.

The common key factors to success are a strong receiver and that the theory was transferred in a tool that was adapted on request from the receiving company. In addition the transfers relied in both cases on a mutual trust.

2.3 University to small product company

The transfer to a small product company can be done in several principal different ways including spin-off companies or transferring of ideas to an existing small company. In this case we will briefly describe a novel debugging technology that was the base for a spin-off company, Success5.

The key to make this kind of transfer is that the researcher has an entrepreneurial mindset or the ability to find a entrepreneur partner, but also that the researchers have established necessary contacts with potential future customer before spinning off. In addition, the environment for the researchers at the university has to be supportive for spin-offs.

In this particular case, the spin-off company had been evaluating the research with one established industrial product company. The company was interested in buying the debugging product if it existed as a real product. This was the base for a venture capitalist to support the startup of the company. The current state of the company is that the customer base has expanded and that a second round of funding has currently been achieved to accelerate the business development.

The keys for a successful transfer are entrepreneur skills and that a business value exists via an active customer that is involve in the product development as a demanding customer and evaluator. To be successful in introducing the product in a company requires that both formal agreements with upper management and that the technology is accepted by the users within the company. Among the users there must be some early adapters that sell the technology inside.

3. A TRANSFER FAILURE

This section gives an example of a transfer failure that had many success factors in place, but still it failed. This indicates that even if focus is on succeeding and all known success factors are considered there might still be a failure in the end due to reasons not clearly envisioned.

The project chosen to illustrate a failure of a transfer is a three year project where the originating university had worked with the target to deploy its results on a large product company. In this example a research unit was deeply involved as a mediator between the transferer and the receiver. In summary the transfer was to happen in two steps, first from the university to the research unit and then continue to the product company.

The objective of this project was to develop a tool that could be used for prediction of real-time properties in an industrial control system.

The transferer in this project worked very closely with the research unit and in the last year of the project even job rotations were used to facilitate the transfer. The product company receiver was involved during the last year after that proof of concept was shown. The technology in itself was of very high standards and used the latest research in real-time analysis. Moreover during the last year frequent meetings between all parties were scheduled. At these meetings the transfer question was often discussed and early on it was identified that technology handover would be difficult. The main reason for this risk was the complexity of the developed technology, the product company could not educate nor spare developers to take ownership of the source code.

The story ends with the solution that the research unit and the university package the tool in an easy to use way for usage, however, the product unit could not take the desired ownership of the tool.

From a university perspective this was a very exciting project where a real world problem was tackled and a solution was found. Both the university and the research unit together fought for transferring the technology, even the product unit did what it could to take over the technology.

Seen from the industrial receiving point of view, it can be identified that the key factor that lead to failure was lack of ability to take ownership of such a complex piece of software, even if the unit had the competence. The underlying reason that the transfer did not happen was that the perceived value of the tool was less than the cost of assigning developers to the cause, i.e. the business case was not strong enough to pursue the product company. In addition this project was carried out in a time were hiring was not an option to reinforce the receiving team.

As a concluding remark we can say that all involved parties were extremely satisfied with how the work was carried out and the failure was not total since the packaged tool came to use. Moreover, performing research is a risk taking business, trying to minimize the risk in the actual product development, and not all projects are expected to succeed.

4. ANALYSIS

We believe that all parties involved actively in a technology transfer project are interested in its success, even though there might be resistance in other parts of a receiving organization. However, interest is not enough to facilitate a successful transfer. In this section we provide factors that we have seen as general among several of the projects that we have studied.

A common factor for success that we have observed is to have a strong receiver that genuinely wants the new technology. However, this is not an absolute guarantee for success as pointed out in Section 3. There are also different perspectives depending on the point of view, i.e. from the transferer's or the receiver's.

The transferor should take every possible action in order to minimize the effort on the receiving end. Examples of such efforts are the encapsulation of complexity in tools, roadmaps describing what actions that are needed to make prototypes into products. Consequently, ease of deployment is as important for technology transfer as ease-of-use is for product design. However, our failure case indicates that not only technical issues have to be considered when providing ease-of-deployment. The effort to take ownership of a technology must also be minimized.

Much of the communication and collaboration can, and should, be driven by the transferer and it is important that part of the communication also should be devoted to real sales work. Having a strong believer selling the technology makes it easier to pursue the receiver to overcome hurdles. Hurdles can be related to intrusion into already established territories in the receiver's organization. On the receiving end it is very important to have both expert and management commitment. Without one of them a technology transfer will fail either with the deployment of the technology or with the business case, both leading to failure.

Another factor that has proven successful, in the cases that we have described, is the rotation of people in conjunction with the technology. In this way the receiver gets the competence needed to maintain and utilize the technology. Moreover, a natural ownership is established at the receiver side.

A big risk when it comes to technology transfer is that expectations from all parties deviate. The transferer and the receiver can have different expectations on the value that the new technology can bring. As a result, trust between the parties can be hurt which inevitable leads to a failure.

5. TRANSFER STRATEGIES

When technology is to be transferred it is possible to take different approaches or strategies on how to achieve the transfer. According to our experience, for a successful technology transfer the technology transfer partners must have a strategy. Our short analysis here identifies several strategies, both from the receiver and transferer point of view.

A general advice is to think early, in the development phase, on how to transfer the resulting technology. However, it is also possible to carry out the technology development first, and then take care of the technology transfer afterwards. During our studies of technology transfers we have seen that technology development projects deals differently with the transfer question. The identified strategies are:

- Intensive collaboration – This implies that there are continuous and frequent meetings with the intended receiver of the technology during the project execution. Even people from both sides can work in the project together.

- User buy-in – The intended users of the technology sees the value of the technology and advocates the transfer.
- Management buy-in – Management at the receiving unit are convinced of the technology value.
- Continuous updates – There are continuous updates about the project progress, given from the transceiver to the receiver, during the project execution. This does not necessarily mean that people from the receiving unit are involved in the project as it is if an intensive collaboration strategy is used.
- Spin-off company – This is mainly used when the technology idea is strong enough to carry a new business case of its own. Maybe the technology is not exactly inline with the strategy of the inventing organization. In this case people often move together with the technology to the new unit receiving the technology. This is very often seen in tool developing scenarios.
- Rotation of personnel – Inside a bigger organization it is often encouraged that people form a research organization follows with the technology out into the receiving organization to facilitate competence build up and jump start product development.
- Hide and complete – Sometimes it is worth to complete the development and then face the transfer problems. Reasons for this can be sensitivity of project both from a political or technology perspective.
- Push down – This strategy can be used if upper management, on the receiving end, takes a top-down decision of particular technology usage. Transferring part can then use that decision to push the technology onto the receiving part.
- Work on-site – The technology development project is executed at the location of the receiver but buy an external organization.
- Neglect – A strategy that is used implicitly if no other strategy is explicitly mentioned in the technology development or transfer project.

Different strategies can be implemented by the transferer, the receiver or both to overcome the hurdles preventing the transfer from happening. When problems occur during the transition it is of value to know what to do and what resources are available to solve the problem. We claim that from a transferer perspective it is of most importance that a transfer strategy is consciously selected, executed and clearly communicated between the parties.

However, having a transfer strategy is not sufficient, a technique must be used to perform the transfer. Different techniques identified from our experience are:

- The receiver goes and gets the technology – If possible this event should be of sufficient length to ensure competence transfer as well as technology transfer. Maybe a job rotation can be used to from the receiver to the transferer.
- The technology developer follows with the technology to the receiver – This can be done in several ways, for instance through job rotation or change of employer.
- Embed technology in tool – A user friendly tool that can be used out of the box will increase the chance of usage immensely. For instance complex algorithms are very difficult to transfer at all, however, algorithms can often be implemented in tools.

In general, transfer techniques that ease the implementation on the receiver side are more useful and successful than others. If the gap between new technology and the used technology, at the receiving side, is too large, the impact of the required change is often insurmountable, i.e. the cost of introducing the new technology becomes the final hurdle that prevents the transfer.

6. CONCLUSION

Successful technology transfer is a function of many critical parameters among which timing is one of the more important. A business unit that stands in front of crucial decisions or problems regarding current- or future technology tends to be receptive for influences from others.

As a transferer it is important to have a clear transfer strategy. In this paper we propose several strategies that can be used, in isolation or combined, in order to increase the probability for success. Moreover, we report several success- and failure factors based on several real cases.

There is often a gap between what is delivered and what the receiver requires in order to make use of the technology. We have seen that an industrial research unit can play the important role of taking not fully matured technologies from academia, find applications for them, and assist in deploying it in the business units' development organizations.

Future work includes a more exhaustive study of our research project database with the aim of extending our list of findings and to confirm our initial findings reported in this paper.

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