Group Cohesion in Modern Verification-Oriented Companies

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Abstract

We investigate group cohesion in modern start-ups whose main product is verifying software correctness. First we describe the main difference between regular start-ups and verification oriented start-ups. We base our observations on studying a sample of several successful companies that are mainly verification oriented. Furthermore, we research group cohesion. We introduce the notion of sociological compatibility and we relate sociological compatibility with affective conflict. We use the fact that cohesion negatively relates to the level of affective conflict to show that sociological incompatibility negatively relates to new venture performance. Finally, we conclude by forming a virtual start-up team taking previous reasoning and conclusions into account.

1 Introduction

In this essay we investigate which challenges and problems might occur when a freshly finished PhD student decides to create his own start-up. Because the main area of research of the author of this essay is software verification, we will shift from a general perspective to a perspective focused on verification-oriented start-ups. We will argue how to form a successful team and what are some new insights that we will take into account when forming a team.

Very close to the moment when PhD students finish writing up their theses, they ask themselves what is the next step in their lives. They are facing the dilemma whether to stay in academia and continue with their research or to go to work in industry and face all the problems of the real world. If they decide for industry, this decision often raises the question what a PhD degree is good for and whether the time spent in a graduate program was potentially wasted. Due to various reasons (for example, the wish to be his own boss or lack of job offers from industry), they often decide to form a new start-up where they plan to apply the technical knowledge that they gained in the graduate program. However, their chances of success are not very high.

As it was recently shown by scientists from the Harvard Business School [Gompers et al. 2008], first time entrepreneurs have only an 18 percent chance of success. The authors argued that the belief that successful entrepreneurs are more skilled than unsuccessful ones (they call this the perception of performance persistence) can actually induce the real performance persistence. Their study showed that first time entrepreneurs have even less chances of success than failed entrepreneurs.

In this light we investigate why a start-up of a freshly finished PhD student has more than 80% chance to fail. Most of the problems that fresh graduates face can at the end be traced back to their inexperience. They tend to start a company which will closely follow the research they did during their PhD studies. Such a decision is not surprising: it is well known that a large fraction of the founders of the Inc.500 [Inc.500] companies got the idea for their new companies while still working at their prior employer [Bhide 2000].

However, technical knowledge is certainly not enough: new start-ups should be driven by demands of the market and customers and not by the technical knowledge of their founders. However, one should not underestimate the role of technical knowledge and assume that only market knowledge is enough. In [Hisrich et al. 2007, p. 430], technical knowledge is identified as one of the basis for generating new opportunities. They also claim that the advanced technical knowledge should be used for creating new markets rather than satisfying the unmet needs of already existing market.

We believe that the lack of knowledge of market and potential customers is the main problem for the freshly finished PhD students as it is hard to define the direction in which their company should go. If they try to create new markets, there is a big chance that their previous work may have been

too theoretical and might not actually create a new market. The time component is also important: one has to have the right idea in the right time. As an example of the company that had the right ideas but in the wrong time is Cerebra^{TM}[Cerebra]. Cerebra have started to develop and commercialize semantic technologies in 2001. Their products were based on the state of the art research in the University of Manchester. However they failed to create a new market and the company is already for some time "in stealth mode". These days research and development of semantic technologies is widely supported with more than 500 millions of Euros [Future Internet video, clip at 5:13].

The other direction that a fresh entrepreneur can take is to try to integrate into an already existing market. "Start by writing software for smaller companies, because it's easier to sell to them." is an advice from Paul Graham [Graham 2005], an experienced entrepreneur. Paul Graham is a co-developer of the first web-based application, Viaweb, developer of a simple statistical spam filter and author of a programming language called Arc.

Thus, each fresh graduate (and each entrepreneur) can direct his start-up either in the unsafe direction of defining new markets or in a slightly safer direction of integration in already existing markets. In the rest of the paper we will show that start-ups whose main product is software verification do not have such a choice.

2 Verification-Oriented Companies

Software is probably one of the most complex artifacts developed by humans and everyone who has ever programmed knows that writing bug-free code is a difficult task.

Discovering and removing software bugs plays also an important role in economy. In a study conducted by the National Institute of Standards and Technology (NIST) [NIST Report], it was estimated that software bugs cost the US economy $59.5 billion a year. The same study also speculates that more than a third of these costs (an estimated $22.2 billion) could be eliminated by earlier and more effective identification and removal of software defects.

Programmers thoroughly test their code. By running numerous tests they discover bugs and correct them. The most expensive bug is the one discovered only after the product has been shipped to the customers. Thus, testing is

a very important part of software development. However, even extensive testing does not guarantee absence of errors. The only way to guarantee that software will behave correctly is by providing a strict mathematical proof of software correctness. Such a proof guarantees the correct behavior for all possible executions of the software. However, the goal of companies doing verification is not to check each peace of code with pen and paper but to produce tools that can do such formal mathematical reasoning automatically.

There are various topics that verification can address and all of them are very hard (formally meaning that the underlying verification problem is undecidable). For example, it is important to see whether the code actually corresponds to its specification, i.e. whether it is doing what it is supposed to do. Also, for programs performing some complex computations, we would like to know whether they terminate and if so, what their worst case execution time is. Most of programs have so-called "bad states". To bad states belong for example, division by zero, or trying to write simultaneously to the same memory location, or accessing an array cell that is out of bounds, etc. There are verification tools specialized in proving that for any given input the program execution will never reach any of those bad states.

It is clear from the description of the verification tasks, that small software companies still do not belong to the customers of verification start-ups. The reason for that is that verification software is very complex and therefore expensive. Small companies that are still fighting for their own market share cannot afford such extra cost. They only test their software before shipping and remove bugs found during that phase. However, big companies that have a market share worth billions of dollars care very much about software verification. Not only that they extensively use verification tools, but they also develop their own tools. Some of the top researchers of verification are working in their research labs. Here we are talking about companies and research agencies like Microsoft, IBM, Intel, HP, NASA etc.

This means that if a fresh graduate who had a PhD project in verification wants to start his own start-up, he has to aim to develop a tool that could be use by a big company. This directly contradicts the advice given by Paul Graham [Graham 2005]: "Avoid starting a start-up to sell things to the biggest company of all, the government. Yes, there are lots of opportunities to sell them technology. But let someone else start those start-ups."

2.1 Examples of Verification-Oriented Companies

Next we briefly describe some of the existing verification-oriented companies. We take three successful companies (one American, one French and one German) and one failed and then we analyze what all those companies have in common and what are their differences.

[Coverity] is a company with headquarters in San Francisco that has over 600 companies as customers, including ARM, Phillips, RIM, Rockwell Collins, Samsung and UBS. The main focus of the company is scalable precision software analysis. The products of the company are used for source code analysis and help programmers to design and develop better and superior software. The company was co-founded by Dawson Engler, a professor at Stanford University. In 2008 he received the ACM Grace Murray Hopper Award for excellence in Software Quality Research. His PhD project was the design and implementation of a new operating system.

[AbsInt] is a German company with headquarters in Saarbrücken, one of the top computer science research centers in Germany. The costumers of AbsInt are some of the biggest German (and international) companies, institutes and universities, including BMW, Siemens, Bosch, Mercedes, VW, Rockwell Science Center, Stanford University, UCLA and many more. The main products of the AbsInt company are analysis and verification tools that run at compile-time. Probably their most famous product is a worst case execution time analysis for verifying that safety-critical applications always react fast enough. The AbsInt company was founded by Reinhard Wilhelm, a full-professor and the chair of the Programming Languages and Compiler Construction group at Saarland University. He is one of the main researchers in the area of compiler construction with more than 100 publications and winner of many professional awards.

[ASTRÉE] is a French company also specialized in proving software correctness and absence of errors. Their tool started as an academic project based on the high-impact research done by Patrick Cousot. Their main product which is also called ASTRÉE is a tailor-made tool for analyzing absence of errors in Airbus' flight control software. Patrick Cousot, a full-professor at École Normale Supérieure, is, together with his wife, the originator of abstract interpretation, one of the most influential techniques used in software verification.

"Cedilla Systems Incorporated" was a start-up founded in 1999. and does not exist any longer. The goal of this start-up was to develop a certified Java

compiler that would come together with an automatic theorem prover. The theorem prover would run on remote clients to certify correctness properties of the code output by the compiler. The founders of the company were all highly educated, successful scientist in the field of compiler construction and verification. (for example, George Necula, one of the founders is now a professor at Berkeley). While the company's work had a significant scientific impact, it did not succeed from an economic point of view and was closed after only one year of existence.

2.2 Discussion

We will now analyze what the above examples of companies that have started as a verification-oriented start-up have in common. We can see that their target customers are big companies and that they were all founded by the experts in the field. However, some of them succeeded, some did not. It is hard to investigate why some companies seize to exist, because usually there is not enough information available so most of our conclusions are based on speculations.

We believe that the reason for the failure of some companies is strongly connected with the fact that their founders do not know the market. They have brilliant ideas but they cannot see that the market is maybe not yet ready for those ideas. In the case of "Cedilla Systems" the idea was revolutionary and we can see its influence in many systems today. However, a theorem prover added to compiler at that time slowed down the compiler significantly so it was hard to find customers to buy their compilers.

This reason for failure can again be traced to the problem of not knowing the market or having the right idea in the wrong time. We therefore conclude that, if one plans to start a verification-oriented company, it is necessary to add a market research specialist to the team. This specialist should also have some education in formal verification, but does not need to be necessarily an expert. It is hard to get some useful information about the needs of market, if a person does not understand formal principles of verification. Thus, a prerequisite for hiring a suitable team member is both experience in customer relationship management and some education in formal verification.

To give a better description of such a team member, we explain in more detail the notion of customer relationship management (CRM). CRM is defined in [Srivastava et al. 1999] as a business process that "addresses all aspects of identifying customers, creating customer knowledge, building cus-

tomer relationships and shaping their perceptions of the organization and its products". This is the precise description of the process that is needed for a successful start-up. A customer relationship manager is a mediator between customers and start-ups. In [Srivastava et al. 1999] they are also referred to as consultants.

The influence of the level of experience on meeting objectives of consultants was investigated in [Hart at al. 2004]. Even though the results of this study failed to establish a link between meeting objectives and level of experience (their correlation was not statistically significant), we still believe that experience plays a role for consultants. We base our beliefs on the example of "Cedilla Systems" start-up and some other companies that failed. In most of the cases there was no experienced customer relationship manager in the team. On the other hand, each of three above mentioned companies has at least one member with more than ten years experience in the field.

To conclude, we saw that verification-oriented start-ups should only go in the direction of creating new markets with big companies as target customers. To do that, their founders have to focus on some aspects of software verification that are not tackled yet by existing tools or they have to develop a tool with significantly better performance than the tools of their competitors. Furthermore, it is hard to create a new market without any experience in entrepreneurship. Thus, we strongly advice each fresh entrepreneur to take in his team an experienced customer relationship manager.

3 Sociological Compatibility

In the previous section we started to build a team in our virtual verification-oriented start-up. In this section we will introduce the notion of "sociological compatibility". This notion applies not only to verification-oriented start-ups but to any team. We strongly believe that this notion plays an important role in group cohesion. Sociological compatibility is not widely used nor investigated in entrepreneurship theory: the only place we have found it was in [Campbell 1987] and even there it is not investigated in the light of group cohesion but in the context of cultural contradiction. Campbell claims that a group that culturally directly contradicts does not necessarily lead to tensions and conflict if their expression is separated in time and space. As an example, Campbell uses the middle-class life cycle. Usually its rebellious and bohemian youth is followed by bourgeois middle-life years.

Even though it is not explicitly stated, Campbell assumes that culturally contradicting life-styles would necessarily lead to conflict if they belong to the same group. We will describe sociological compatibility as as more general term that does not depend only on cultural life-style. Still, we will use the assumption from [Campbell 1987] and formulate it as Lemma 1 that a sociologically non-compatible group will lead to affective conflict. As it was shown in [Ensley et al. 2002], group cohesion is negatively related to affective conflict. In the same paper it was also shown that group cohesion is positively related to new venture growth. Therefore, in order to increase growth, we suggest to form a team that is as sociologically compatible as possible.

We call a team "sociologically compatible with respect to a criterion X" if the following holds: after dividing the team into disjoint subgroups based on criterion X, all resulting subgroups have approximately the same size. For example, a team of ten females and a team of four females and six males are sociologically compatible with respect to sex, while a team of two females and eight males is not. It is clear that such a definition makes sense only for a group of a certain size.

We call a team "sociologically compatible" if it is compatible with respect to age, sex, education and emotional stability. The scheme depicting dependencies of factors that lead to the start-up growth is shown in Figure 1.

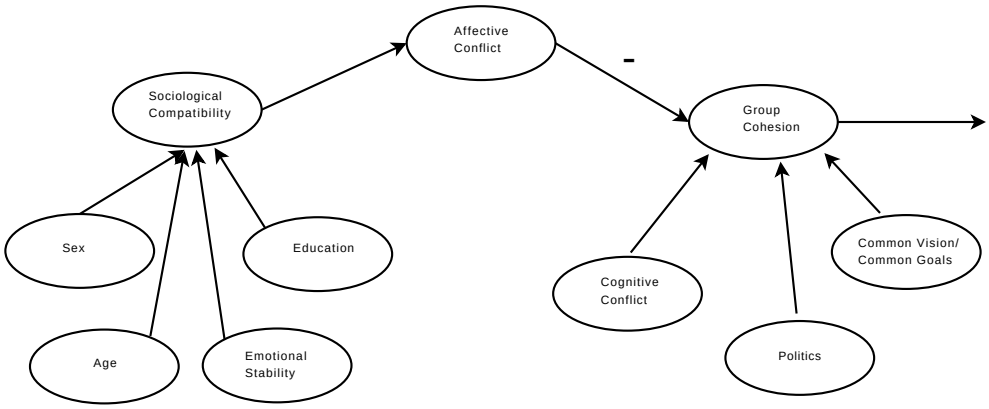

Figure 1: If a team is completely sociologically compatible, then it does not influence affective conflict at all. Using the facts that affective conflict is negatively related to group cohesion and that group cohesion is positively related to the venture growth, we conclude that a completely sociologically compatible team contributes to venture growth

Note that by introducing sociological compatibility we do not advocate homogeneous groups. It was shown in [Hornaday 2001] that even though group cohesion, consensus and potency are not affected in all male teams, it can have different effects on a team performance. The fact that group cohesion is not affected in all-male teams did not come as a surprise, because those teams are sociologically compatible with respect to sex.

The reason why we have chosen sex, age, emotional stability and education as relevant factors to define sociological compatibility is based on the observation that with respect to these criteria people tend to form subgroups that exclude others. Dynamics and behavior of subgroups were already studied in [Moreland & Levine 2001], but in that paper the authors focused on the temporal dimension of subgroups. They investigate how people tend to form subgroups based on projects they did together in the past. We believe that this is not relevant for the sociological compatibility. We see sociological compatibility as a measure of factors that an individual team member has before joining the team, informally saying " something that he brought from home". Based on the previous common working history team members might form subgroups at the beginning of a project. Those subgroups dissolve as a project progresses and new subgroups are formed based on the current status of a project, as was shown in [Moreland & Levine 2001].

A more detailed model of sociological compatibility could also include factors as nutritious habits. As an example, if there is only one vegetarian in a group and there are no restaurants serving vegetarian dishes nearby, probably this person will not get invited very often for lunch.

Another factor that could also be taken into account are leisure activities. For example, golf is a favorite pastime of corporate CEOs. In [Rynecki 2007] numerous CEOs (Jack Welch, Bill Gates, Warren Buffett, Sandy Weill) confirm that golf clubs are places of communication as well as places for sealing business deals. Leisure activities with similar characteristics include hunting and sailing.

We believe that today ethnic origin does not play anymore a vital role in subgroup identification. This is particularly true in the context of high tech companies where employees are highly educated and tend to be more liberal. For this reason we exclude this criteria from our consideration.

We can measure the sociological compatibility of a team by ranking the criteria and assigning them weight. Based on those weights we can calculate the sociological compatibility of a team. Note that all criteria can be measured. Once we calculate the measure of the sociological compatibility, we

will be able to validate the following lemma:

Lemma 1 *In each team sociological compatibility negatively relates to the level of affective conflict.*

To validate this lemma we would need to run a series of tests and questioners. Our beliefs that this lemma is true are based on the following observations:

People tend to form subgroups because they feel more protected and secure as a member of a bigger team than as an individual. If there is a subgroup that is significantly smaller than others then this situation can invoke rivalry and affective conflict. As an illustration, if a team consists mostly of younger people and only two older members, yet, all the team members are on the same level in the corporate hierarchy, most likely this constellation will lead to affective conflict. However, if a team would have approximately the same number of older and younger members, no age-based conflict would occur.

3.1 Other Factors That Influence Group Cohesion

In Figure 1 there are some other factors that influence group cohesion. We use their standard interpretation as it is defined, e.g., in [Ensley et al. 2002], so we do not describe them in details. We have just listed these factors to stress their importance for group cohesion. The cognitive conflict is a conflict that is oriented towards tasks and it is focused on deriving the best strategic decision. In [Ensley et al. 2002] it was shown that cognitive conflict positively relates to group cohesion. In the same paper also a relationship between cognitive and affective conflict is explored.

4 Conclusions

In this essay we presented two aspects: we described verification-oriented start-ups and we introduced the notion of sociological compatibility. We conclude the essay by applying the previous observations to form a virtual verification-oriented start-up.

Our analysis of successful verification-oriented companies has revealed that they were all founded by experts in the field. However, as we pointed out in Section 2.2, technical excellency alone is not enough to guarantee the

success of a start-up. In addition, a knowledgeable expert that is able to assess the needs of the market is an indispensable team member.

When the company grows and the number of its employees increases, criteria that influence group cohesion become more and more important. We identified the notion of sociological compatibility as a measure that helps the management to reduce the level of affective conflict within teams and thus stimulate further company growth.

References

[Bhide 2000] Amar Bhide, *The Origin and Evolution of New Businesses*. Oxford: Oxford University Press. 2000.

[Campbell 1987] Colin Campbell, *The Romantic Ethic and the Spirit of Modern Consumerism*. Oxford: Basil Blackwell, 1987.

[Ensley et al. 2002] Michael D. Ensley, Allison W. Pearson, Allen C. Amason, *Understanding the dynamics of new venture top management teams: cohesion, conflict, and new venture performance*, Journal of Business Venturing, 17 (2002), July 2002.

[Gompers et al. 2008] Paul A. Gompers, Anna Kovner, Josh Lerner, and David S. Scharfstein, *Performance Persistence in Entrepreneurship*, Harvard Business School, Working Paper September 2008.

[Graham 2005] Paul Graham, *How to Start a Startup*, March 2005., available at `http://www.paulgraham.com/start.html`

[Hart at al. 2004] Susan Hart, Gillian Hogg, Madhumita Banerjee, *Does the level of experience have an effect on CRM programs? Exploratory research findings*, Industrial Marketing Management, Volume 33, Issue 6, August 2004, Pages 549-560

[Hisrich et al. 2007] Robert D. Hisrich, Michael P. Peters, Dean A. Shepherd, *Entrepreneurship*. McGraw-Hill Education Singapore; 7th edition. 2007.

[Hornaday 2001] Robert W. Hornaday, *Sex composition, cohesion, consensus, potency and performance of simulation teams*. Developments in Business Simulation and Experiential Learning, Volume 28, 2001.

[Moreland & Levine 2001] Richard L. Moreland, John M. Levine, *Socialization in organizations and work groups*. In M. Turner (Ed.), Groups at work: Theory and research (pp. 69-112). Mahwah, N.J.: Erlbaum. 2001.

[NIST Report] Michael Newman, *Software Errors Cost U.S. Economy $59.5 Billion Annually*. NIST Planning Report 02-3, May 2002., available at `http://www.nist.gov/public_affairs/releases/n02-10.htm`

[Rynecki 2007] David Rynecki, *Deals on the Green: Lessons on Business and Golf from America's Top Executives*, Portfolio Hardcover, April 2007.

[Srivastava et al. 1999] Rajendra K. Srivastava, Tasadduq A. Shervani, Liam Fahey, *Marketing, business processes and shareholder value: An organizationally embedded view of marketing activities and the discipline of marketing*, Journal of Marketing, Special Issue 63, p. 168 - 179., 1999.

[AbsInt] `http://www.absint.com/`

[ASTRÉE] `http://www.astree.ens.fr/`

[Cerebra] `http://www.cerebra.com/`

[Coverity] `http://www.coverity.com/`

[Future Internet video] `http://www.future-internet.eu/publications/media.html#c140`

[Inc.500] `http://www.inc.com/`