The top ten similarities between playing hockey and building a better Internet (extended version)

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Time tends to pass more quickly than we would like. Sometimes it is helpful to reflect on what you have accomplished, and to derive what you have learned from the experiences. These "lessons learned" may then be leveraged by yourself or others in the future. Occasionally, an external event will motivate this self reflection. For me, it was the 50th anniversary reunion of the St. Walburg Eagles, held in July 2011. The Eagles are a full-contact (ice) hockey team I played with between 1988 and 1996, while attending university. What would I tell my friends and former teammates that I had been doing for the past 15 years? After some thought, I realized that my time as an Eagle had prepared me for a research career, in ways I would never have imagined. This article shares some of these similarities, to motivate others to reflect on their own careers and achievements, and perhaps make proactive changes as a result.

The top ten similarities between playing hockey and building a better Internet (extended version)

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ABSTRACT

Time tends to pass more quickly than we would like. Sometimes it is helpful to reflect on what you have accomplished, and to derive what you have learned from the experiences. These "lessons learned" may then be leveraged by yourself or others in the future. Occasionally, an external event will motivate this self reflection. For me, it was the 50th anniversary reunion of the St. Walburg Eagles, held in July 2011. The Eagles are a full-contact (ice) hockey team I played with between 1988 and 1996[1], while attending university. What would I tell my friends and former teammates that I had been doing for the past 15 years? After some thought, I realized that my time as an Eagle had prepared me for a research career, in ways I would never have imagined. This article shares some of these similarities, to motivate others to reflect on their own careers and achievements, and perhaps make proactive changes as a result.

Introduction

When I first started working for HP Labs (in 1997), my friends and family in rural Saskatchewan would all ask me what I was working on. If I told them I was characterizing the workloads of Web servers or evaluating the performance of Web proxies, the typical reaction was a puzzled look. So when I went home for Christmas that first year, I decided to describe my work in a slightly different manner. When my uncle Bob (a carpenter who takes great pride in building things quickly and correctly) asked me what I was working on, I said I was trying to make the Internet go faster. He said that was good, because his "Internet" was really slow. The following Christmas I saw my Uncle Bob again. One of his comments was "Well Martin, the Internet still sucks!", meaning that I still had a lot of work to do.

In a nutshell, "building a better Internet" summarizes the motivation behind much of the work in the entire SIGCOMM community for the past several decades. My intent with this editorial is twofold: to share my "lessons learned" with the community, particularly with new members seeking to establish themselves; and to motivate other seasoned veterans to share their experiences.

My Eagles career started one day while I was working at the hardware store in my home town of Loon Lake, Saskatchewan. Loon Lake did not have a team in the local senior hockey league, and since the World Wide Web hadn't been

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[1]The Eagles ceased operations twice during this period, which limited me to four seasons playing with them.

invented yet, I had no idea who to talk to about joining a team in a different town. Fortunately, opportunity knocked. The hardware store owner had made an arrangement with a gentleman from St. Walburg to stop by the store once a week and sharpen skates. This man happened to be the father of the Eagles' captain. We started talking about hockey, at which point he asked me if I knew anyone who might be interested in playing for the Eagles, as they were looking for a few more players. I told him I knew of one!

Almost a decade later, hockey helped me land a job at HP. An HP Labs researcher read a paper that I had published at ACM SIGMETRICS. By coincidence, his manager was a huge hockey fan. Playing hockey helped differentiate me from all of the other people that he interviewed that year, and helped get me in the door. Years later, I asked him about this. He indicated that some of my hockey accomplishments demonstrated that I was very tenacious, which was a characteristic he looked for in the people he hired.

How the Internet is like hockey

Since (ice) hockey is not the most popular sport in the world, I'll provide a brief overview. I'll also point out some similarities between the Internet and the game of hockey.

The Internet involves a lot of infrastructure: data centers to house servers, client devices to interact with the servers, and fiber optic and wireless networks to connect them. Hockey also requires a significant amount of infrastructure. Hockey is played on a rectangular sheet of ice, typically inside a building called an arena or a rink. In North America, the ice is 200' long by 85' wide; in most of the rest of the world, it is 15' wider. Figure 1 shows the layout of the playing area of an arena.

A game involves two teams, each defending a goal at opposite ends of the ice. For the team defending the goal on the right-hand side of Figure 1, the right-most third of the ice (from the rightmost blue line to the right-side of the figure) is called their "defending zone". The area between the two blue lines is the "neutral zone". The remaining third of the ice (from the leftmost blue line to the left end of the ice) is their "attacking zone". Each team plays with 5 players (left wing, center, right wing, left defense, right defense) and 1 goaltender (goalie for short) on the ice at a time. The remaining players on the team sit on the team's "players bench". The objective in hockey is to put a small rubber disk called a "puck" into the goal in the attacking zone more times than your opponent puts the puck into your goal. For a "goal" to count, it must be shot into the goal

with a "stick"; it cannot be thrown or kicked in.

The game of hockey has a number of similarities to how the Internet operates. First, there are flow control mechanisms that attempt to maintain a desired pace. In hockey, there are two forms of flow control. "Icing" occurs when a defending team shoots the puck from their half of the ice (the middle is denoted by the center red line) all the way past the goal line in the attacking zone. "Off-sides" occurs if a player enters their attacking zone before the puck crosses the blue line between the neutral zone and the attacking zone. (In contrast to football/soccer, the positioning of the defending players does not matter.) Two on-ice officials called linesmen are responsible for implementing these flow control mechanisms.

Second, there are "rules of engagement" that attempt to deter undesirable activities. As with the Internet, some participants will "bend" the rules to try and gain an advantage for themselves. Like a network protocol specification, there are a lot of possibilities to cover. Although too numerous to mention here, the rules can generally be categorized as mechanisms to deter "impeding the movement of an opponent", "excessive physical aggression against an opponent", "excessive use of a stick against an opponent", and "other undesirable behavior". A "referee" is an on-ice official responsible for enforcing these rules. Minor infractions result in a player serving (up to) two minutes in the penalty box; infractions deemed more serious by the referee can be given a major penalty (5 minutes) or a misconduct (10 minutes), or even the remainder of the game (that's like having your Internet access turned off for for a day for downloading too much content). If a team is assessed a minor or major penalty, they go on the "penalty kill" and play "short-handed" for the duration of the penalty, while the other team goes on the "power play".

To explain what it takes to get a misconduct penalty, here is an example. The Eagles were having an inter-squad game. It was the opening faceoff. Dwight "Too Tall" Hall was one of the centers. The referee was being incredibly picky about how the players lined up for the faceoff, and was continuously instructing players on both sides to move an inch or two this way or that way. After about 60 seconds of this, Too Tall said to the ref, "Are you going to drop the puck, or take a picture?" The referee failed to see the humor in that comment, and as a result Too Tall was assessed a 10 minute misconduct.
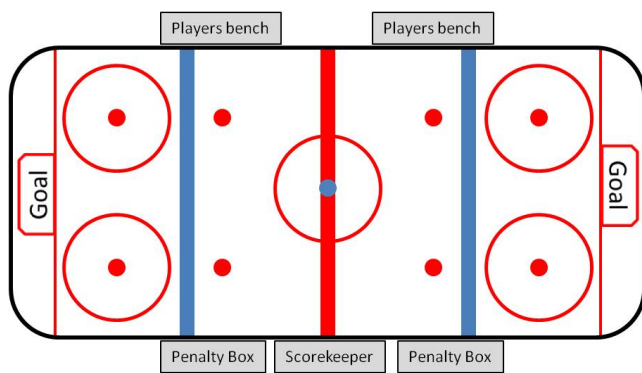

Figure 1: Layout of an ice hockey playing area.

The top ten similarities

While I was preparing this material, I realized that there were a lot of similarities between playing hockey and conducting research to build a better Internet. I chose to limit the comparison to the following ten.

10. Team Work

Playing hockey and building a better Internet both require teams of skilled individuals. Some members are specialists at certain roles, while others are good at almost everything (e.g., the Eagles captain, Doug Trotzuk, played all positions other than goaltender; he could score, hit, fight, or do anything else that the coach asked). There are leaders and followers, rookies and veterans. Everyone contributes to a shared objective in their own way. Figure 2 and Figure 3 show two of the best teams I've ever been on. Both have members possessing the characteristics that I just described. The only real difference is the hair styles. While somewhat difficult to see in Figure 2, the "mullet" (short on top and sides, long in the back) was the common choice on the Eagles, but is extremely rare at HP.
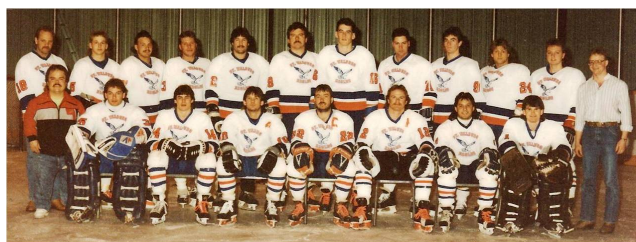

Figure 2: St. Walburg Eagles, 1990-1991 season.

Figure 3: HP Labs Sustainable Ecosystems Research group, December 2010.

9. Climate controlled environments

As previously mentioned, hockey is played in an arena or rink. Figure 4 shows the St. Walburg arena where the Eagles play their home games. When I was a child, most of the rinks I played on used "natural" ice. That is, they relied on the long, cold Canadian winters to keep ice in the rink for the entire hockey season. While very cost effective, the occasional warm air front would affect the quality of the ice and interrupt the hockey season. Today, arenas typically have refrigeration systems to improve the availability of the ice, albeit at a much higher cost than "natural" ice.

The Internet also depends on climate-controlled facilities, particularly for the data centers that house servers and networking equipment. Without the refrigeration systems, the IT infrastructure would overheat and the availability of the Internet could be interrupted. Some of the larger data centers, such as Google's data centers at The Dalles, Oregon, look a lot like hockey arenas.

Figure 4: St. Walburg arena.

8. Effective planning

Achieving challenging objectives requires effective planning and execution. Perhaps the simplest, most effective plan I've ever seen was the Eagle's game plan for defeating the Meadow Lake Stampeders, one of our competitors in the "Big 4 Hockey League". Our plan had only two steps, which I'll state exactly as they were written by our coach on the chalkboard in our dressing room: 1) piss off Diesel. 2) score on the power play. (For Computer Scientists, the implied third step is "repeat".) Diesel was perhaps the Stampeders best defenseman. However, he had a very bad temper. We repeatedly managed to find a way to aggravate him, and each time he would do something to be assessed a penalty. As evidence that we managed to execute on this plan, see the newspaper headline in Figure 5.

Effective planning is also important for successful research. As an example, the team I am on at HP Labs is developing a "net-zero" energy data center. Part of the solar array for it can be seen in Figure 6. The plan for this data center involves three steps: 1) "avoid doing nothing"; i.e., trying to keep the infrastructure as busy as possible, to obtain the best return on investment; 2) "do nothing well"; i.e., minimize operational costs if no work is being done; and 3) "stick to the energy budget"; our renewable energy supply is very limited, so we need to use it carefully, and minimize how much we borrow from the grid as we need to quickly repay it to maintain our net-zero energy goal.

This is a very similar plan to the one used by almost every hockey arena. 1) arenas are expensive to build and operate, so have games (and hence revenue) as often as possible; 2) when there are no games on, turn off everything that uses electricity; 3) when the revenue isn't enough to pay the power bill, then take out the ice (i.e., turn off the refrigeration system) until the next hockey season rolls around.

Figure 5: Meadow Lake Progress article, 1991.

7. Creativity

A challenge we all face as researchers is coming up with novel solutions to problems. The same challenge exists when playing hockey, as your opponents will usually adapt. It is important to remember that a solution does not have to be sophisticated to be effective.

Figure 6: HP Labs photovoltaic array.

I was never the most creative player on the ice for the Eagles. However, there was one situation that I applied my creativity to achieve a desired solution. There is a cult classic movie about hockey called "Slapshot". Three central figures in this movie are the "Hanson brothers". All three have long mullets and wear black glasses with white tape around the nose piece, creating a distinctive look for these aggressive hockey players. What most people do not know is that the fourth Hanson brother played in the same league as the Eagles. Well, he wasn't an actual Hanson brother, but he looked and played like them. Before one game against his team, I went to a costume store and bought 20 pairs of black framed glasses, and put white tape around the nose piece of each. My plan was to have every player on the Eagles wear them on the ice for warm-up, but our coach thought that might not be the best idea, even though some of the guys looked a lot like the Hansons with the glasses on. Instead, he gave the glasses to some of our fans. They quickly made a few signs, all to focus "Hanson's" attention on them. Even his own team found this extremely funny. I'm not sure how he figured out I was the guy who orchestrated this, but on my first shift he came straight after me. He got ejected from the game, so I guess my plan to get him off his game worked.

Simple ideas can also be effective in Internet research. In the early 2000s, I attended a talk from a group in HP Labs who were working on improving the energy efficiency of data center cooling. I started thinking how would my dad (the original MacGyver) solve this? My proposal, based on the problem constraints I was aware of, was to have the doors on the backs of the racks of IT equipment tilt backwards, to reduce the mixing of hot and cold air in the data center. A member of the cooling group simulated this, and found that it lowered the data center temperatures by 4 degrees Celsius, a very significant reduction for such a simple solution.

6. Disagreements with officiating

In hockey, disagreements with the officiating are commonplace. Sometimes it is over a call that was made; in other cases, it is about a call that was not made. For example, the team photo shown in Figure 7 was taken about 10 minutes after I was hit in the face by an opponent's stick (a penalty, even if accidental); the referee was only about 6 feet away when it happened, but did not call a penalty. I, bleeding from my nose and chin, loudly voiced my disagreement with his assessment.

On rare occasions, bad officiating decisions go in your favor. The Eagles were playing a road game (i.e., in our opponent's arena), and we were in the opponents zone. One of our defensemen shot the puck towards the net, but high off the ice. Somehow, our captain reached his stick up, way

over his head, and deflected it down, and straight into the goal (this is not allowed, as a player may only contact the puck with their stick below the height of their shoulders). Only three people in the entire arena did not see this - the referee and the two linesmen. Our opponents and all of their fans loudly voiced their displeasure, but the goal stood. I still remember the smirk on our captain's face as we skated back to the bench.

On even rarer occasions, can you extract some revenge for bad calls. In a different road game, the linesman called a play offsides that clearly was not. As he skated by the linesman, Dwight "Too Tall" Hall made a comment to him. The referee, on the far side of the ice by the penalty boxes, heard the comment, and quickly skated across the ice. As he approached our bench, he began yelling "number18 blue, you've got 10!!" Before he could finish, Too Tall jumped off the bench and over the boards, and skated straight at him, with the most intense game face I've ever seen. Too Tall never touched the ref, but skated within an inch of him, on his way past him to the penalty box. For a moment though, the expression on the referee's face was one of pure regret for having made that call.

Similarly, I expect every researcher reading this editorial has had disagreements with officials. In many cases, these are in response to comments or decisions made by anonymous reviewers regarding conference or journal submissions. My personal record for a prolonged disagreement involved a patent application. After 7 rebuttals, 1 appeal, 4 different attorneys representing us and the departure from HP of three of the original inventors, we finally resolved our differences and were granted a patent, almost nine years after the application was filed.

Figure 7: St. Walburg Eagles, 1989-1990 season.

5. Show up to win

In 1991, the Eagles created themselves a place in hockey history by winning a best-of-five playoff series 0 games to 2. We were playing the North Battleford Barons in the first round of the playoffs. The first two games were very physical, and both were won by the Barons. However, the Barons refused to play the third game, back in St. Walburg. They told the league that we were too rough, and that the league should eject our entire team from the series and award it to them. Fortunately, the league did not agree with their logic, and refused. We won the series when the Barons forfeited, as shown in the newspaper headline in Figure 8.

A very similar event happened in my work with HP. My colleagues and I were involved in a project to resolve several performance issues with the Internet site of a large company.

One night, my colleagues and I figured out the root cause of one of the problems. When we reported what we had found the next morning, a different group from another company involved in the project refuted our claims, stating they simply could not be the root cause of that particular problem. The customer eventually asked both groups to come to their data center and work through it together. To make a long story short, my colleague and I showed up, but the other group did not. When the meeting time came and went, the customer said "I guess we know what the problem is."

Barons forfeit Big 4 series

Figure 8: North Battleford News Optimist article, Feb. 27, 1991.

4. Social networking

Sometimes it is not what you know, but who you know. People often overlook the fact that hockey is a great social networking tool. During my tenure with the Eagles, I played with farmers, truck drivers, oil rig workers, a lawyer, two morticians (both of whom were goalies!), an EMT, a scuba instructor, several former professional hockey players, and numerous others. One story in particular that I'd like to share is regarding Doug Ashton (the player holding the stick in Figure 9). He was an RCMP officer stationed in St. Walburg when he played for the Eagles. A few years later, I was at home in Loon Lake for the weekend. My aunt called my parent's house, and asked if we could come down to her restaurant to help prepare a very large food order from the RCMP (Royal Canadian Mounted Police). There had been a hostage taking just outside of town, and the RCMP had flown in the Emergency Response Team (ERT) from Regina. When the food was ready, I took it over to the RCMP station. When I walked in, one of the ERT members was walking out - it was Doug Ashton. Fortunately, the hostage situation was resolved peacefully. I found out later that the hostage taker was also someone I knew, a former junior high school classmate.

Social networking is a very important aspect of life in the research community. Whether it is for assistance with a particular aspect of a research project, finding program committee members for a workshop or conference, or numerous other tasks that require expertise that someone else possesses, it is important to develop a social network.

Figure 9: St. Walburg Eagles, 1995-1996 season.

3. Quantifying performance

Hockey leagues often keep very detailed records of various attributes of the game. With the Eagles, it was no exception. Some years, like 1990-91 (Table 1), we did very well. The 1995-96 team, after a 4 year hiatus from playing in the league, was a different story; one win in 24 games (Table 2).

However, statistics do not always tell the whole story. In 1989-90, the Lloydminster Border Kings finished in first place, with a record of 29 wins and only 3 losses. That season the Eagles finished in sixth place, with 14 wins, 16 losses and 2 ties. Based on those statistics, the Vegas odds makers would have expected the Border Kings to easily defeat us in a best-of-five playoff series. However, regular season standings do not mean much in the playoffs. We played a physical game, put lots of pressure on their defense, and rode a hot goaltender (59 saves in our game one win alone) to victory over the Border Kings, winning the series 3 games to 1. Figure 10 shows the headline from the Lloydminster newspaper following our series clinching victory.

Performance evaluation is an essential tool in Internet research. It is difficult to demonstrate if improvements have been without it. At the same time, it is important to remember that statistics do not always tell the whole story.

Table 1: 1990-1991 Big 4 League final standings.

Team	Wins	Losses	Ties	Points
Turtleford Tigers	19	7	0	38
Lloydminster Border Kings	18	7	1	37
St. Walburg Eagles	17	9	0	34
Cut Knife Colts	17	9	0	34
North Battleford Barons	16	9	1	33
Meadow Lake Stampeders	14	11	1	29
Paradise Hill Hawks	12	13	1	25
Maidstone Jets	9	16	1	19
Lashburn Flyers	4	21	1	9
Edam 3 Stars	2	24	0	4

Table 2: 1995-1996 NSRHL final standings.

Team	Wins	Losses	Ties	Points
Maidstone Jets	20	4	0	40
Cut Knife Colts	18	6	0	36
Turtleford Tigers	17	6	1	35
Neilburg Monarchs	14	9	1	29
Edam 3 Stars	11	10	3	25
Paradise Hill Hawks	12	12	0	24
Lashburn Flyers	7	16	1	15
Glaslyn North Stars	5	19	0	10
St. Walburg Eagles	1	23	0	2

Figure 10: Lloydminster Meridian article, March 25, 1990.

2. Anticipation

There is a hockey phrase that is commonly used in business: skate where the puck is going, not where it's been. In other words, you need to anticipate what is going to happen, so that you can take advantage of it. The best example from hockey I can think of happened in a first round Eagles playoff game, and is another piece of hockey history.

In the 1989-1990 season, the Big 4 hockey league used a round robin format for the first round play off series. Two pools of three teams played off, with the top two teams from each pool advancing to the semi-finals. The round-robin games were played like regular season games; if tied after three periods, then a five minute sudden death overtime periods was played. If still tied, then each team received one point. Our final first round game was against the North Battleford Barons. They had to win the game to advance to round 2, we only needed a tie. After three periods, we were tied. In overtime, we took a penalty with only a few minutes left. The Barons really poured on the pressure. My teammates who were killing the penalty were unable to get the puck out of our zone, to alleviate the pressure and enable them to change. From my vantage point on the bench, it seemed like an eternity. Finally, one of our players got control of the puck and shot it down the ice. One of our penalty killers, Curt Pylypow (right-most player in Figure 7), suddenly skated as hard as he could down the ice. I was thinking to myself, he needs to change, he's exhausted! However, Curt had realized that the Barons had pulled their goalie for an extra attacker, and anticipated that when the Eagles iced the puck, the Barons power play unit would not only change for rested players on their bench, but that they would expect the Eagles to change their penalty killing unit as well, since it had been on the ice for so long. Anyway, Curt beat everyone down the ice, and scored a short-handed, empty-net, playoff-series winning goal in overtime - a very rare feat. I contacted the Hockey Hall of Fame to try and confirm that this is a hockey record, but so far they have not gotten back to me; perhaps they are still checking.

Anticipating how Internet technologies (or their use) might evolve is a meaningful skill possessed by successful researchers. Recognizing how things might unfold over time enables researchers to identify problems that may be delaying a desired state from being reached. The earlier a researcher can anticipate these, the greater their potential reward.

I cannot claim to have the level of anticipation of my team mate Curt, or of many of my other teammates or HP colleagues. However, there was one event during grad school where I managed to make a difference, because I anticipated what was going to happen unless I acted quickly. One cold January morning in Saskatoon, SK, I went into school at my regular time (about 7am). I don't recall the exact date, but I do remember that it was about -40C outside. The graduate student computers were located in a raised floor data center. Normally the room was maintained around 20C, but that morning as soon as I opened the door I knew something was seriously wrong, as it was at least 50C. I also knew that if I didn't cool off the room, a lot of the computers would suffer permanent damage, if they hadn't already. There were not a lot of people around at that time of the morning, but fortunately the one person I found was the janitor, who had a key for the loading dock that was directly across the hall from the data center door. We opened up the doors, and let the -40C air roll in. It was perhaps the first use of outside air to cool a data center. Anyway, we managed to save all of the computers in that room. We later discovered the root cause of the hot data center; someone on campus needed to

do maintenance on the chiller that provided chilled water to all of the buildings on campus, and figured that since it was -40C out, that no one would be running air conditioners. Today, the use of outside air in data centers is much more common, including at the HP Labs data center, as it is seen as a means for reducing the cost of cooling.

1. Having fun

Most people who play hockey do so because it is a lot of fun. In some cases, the players also contribute to the enjoyment of others. For example, the Eagles goaltender in 1989-1990, Kevin Armstrong, would do a handstand after each victory, as shown in Figure 11, for the amusement of the fans.

Helping to build a better Internet can be a lot of fun too. As an example, in 2010 several colleagues invited me to co-author a paper on powering a data center using farm-waste. Unlike solar or wind, farm waste can provide a 24x7 supply of renewable energy. The manure is converted to methane, and the methane can be burned to produce electricity. A data center needs lots of electricity to power the servers, but it also needs lots of cooling, to keep the servers from overheating. Often, this comes from using more electricity; however, in the farm-waste design, the waste heat from the power generators would be used to produce chilled water, making the cooling process much more efficient. So, not only will the data center run on a renewable energy supply, but it would need less power than a typical data center. The attention this work received publicly has been astonishing. It was covered in 175 newspapers world-wide, it was on the radio, the Web and TV, including CNN. In 2011, HP won a SABRE award for best PR campaign, which was based on the farm-waste data center. People from various places and backgrounds have contacted me about this work.

As part of my involvement with the farm waste work, I was invited to a feedlot at Hairy Hill, AB, which is about a three hour drive from St. Walburg. The digesters on the feedlot (Figure 12) currently generate 2.5 MW of electricity, which is sold to the local utility. There is an additional 2.5 MW supply of manure available. The owners are keenly interested in building a farm-waste powered data center there, to make use of this "stranded" renewable energy source.

Figure 11: Victory celebration.

Parting shots

For readers not yet convinced of how much I like hockey, Figure 13 shows me in the rink in my basement. It is decorated with jerseys of professional players I've been fortunate

Figure 12: Anaerobic digesters under construction.

enough to meet or play with over the years, some of whom have won the Stanley Cup, one of hockey's top awards.

A few people in the research community who have heard some of my hockey experiences wonder why I voluntarily played a sport that seems so dangerous. My response to them is that playing full contact hockey was safer than hanging out with my friends in my home town. Unfortunately for me, my days of playing contact hockey are behind me. However, this season I am an assistant coach for the Carstairs Redhawks, a team in one of the best amateur hockey leagues in Canada. Coaching is a lot different than playing, but seems to have numerous similarities to managing a research project. However, that is a topic for a future paper.

Figure 13: The author in his basement rink.

Acknowledgments