

## TEACHING NOTE

# Grok: Action Intelligence for Fast Data<sup>1</sup>

## Structure of the Case

The case begins by describing Jeff Hawkins' life history, which provides interesting clues to the making of a serial entrepreneur. Jeff Hawkins has two (professional) passions in his life: mobile computing and neuroscience. Hawkins' strong interest in brain theory was first aroused by a 1979 *Scientific American* article written by Nobel Laureate Francis Crick (co-discoverer of DNA's double-helix structure with Jim Watson). However, Hawkins' early efforts to study how the brain works were rebuffed by his supervisors at Intel, and his subsequent application to pursue a PhD in computer science was rejected by MIT. Later, he enrolled in and then left the biophysics doctoral program at the University of California, Berkeley after the faculty refused to sponsor his thesis proposal on a theoretical mathematical approach to understanding the brain.

Hawkins eventually found a more supportive environment at GRiD systems, where he created a high-level programming language for application development, the handwriting recognition software Grafitti, and the GRiDPAD (a tablet laptop computer) during his tenure with the company. In the early 1990s, Hawkins left GRiD to start his first new venture, Palm Computing (maker of the PalmPilot), only to leave after Palm was acquired by 3Com in 1997. His second venture was Handspring, where he launched the Visor and then the Treo (an early smartphone). When Handspring merged with Palm's hardware division in 2003, Hawkins decided it was finally time to return to his passion for neuroscience, and he founded the nonprofit Redwood Neuroscience Institute. Listed under Additional Resources (#2) is a series of clips from Hawkins' lecture at Stanford University, where he talks about his life as a "reluctant entrepreneur."

The next section (*Hawkins' Fourth Venture—Numenta/Grok*) describes the founding of Hawkins' current company, originally known as Numenta. The text starts by providing information on Numenta's management team and its hierarchical temporal memory (HTM) technology (both key resource endowments). Dileep George developed the mathematical breakthrough that enabled the operationalization of Hawkins' brain theory, and initially served as CTO. Donna Dubinsky, Hawkins' long-time business partner (Palm and Handspring), was the third co-founder and the company's first CEO. In May 2012, Numenta hired Rami Branitzky to take over as CEO and oversee the company's transition from the research and development stage into product commercialization (Ms. Dubinsky remains actively involved as board chair). The case also devotes significant space to explaining what HTM is and how it differs from artificial intelligence (AI).

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Professor Frank T. Rothaermel prepared this case from public sources. This case is developed for the purpose of class discussion. It is not intended to be used for any kind of endorsement, source of data, or depiction of efficient or inefficient management. All opinions expressed and all errors and omissions are entirely the author's. The author thanks Matt Hoepfer (GT MBA '10 and GT PhD candidate in Engineering), Mike Janovec (GT MBA '11), and Vipul Singh (GT MBA '10) for research assistance and Professor Marne L. Arthaud-Day for editorial assistance. © Rothaermel, 2013.

The case goes on to discuss the progress Numenta has made since its inception, including its current business strategy and corporate partnerships. In 2007, Numenta released NuPIC, a platform for HTM implementation that ran on Windows, Linux, and Mac OS X. Initially, Numenta provided a dual-licensing structure (with free access to researchers) to encourage the emergence of a developer community. The company released its second-generation software, based on newer HTM algorithms, for beta testing in 2011. Existing NuPIC users had the choice to either adopt the newer version, or continue using the legacy software without the benefit of Numenta's support. In May 2013, Numenta took on the name of its fledgling product (Grok), officially signifying its transition from a research and development company to a commercial enterprise. Early adopters are exploring applications ranging from video monitoring and image analysis, to optimizing energy reserve markets and monitoring wind farm operations.

The final section of the case addresses the challenges Grok faces currently. Whether or not software patents should be permitted has been a subject of great debate (the State Street Bank decision) and changing legal opinion. The case therefore discusses patent law and the process of obtaining a patent, as well as the effectiveness of patent protection in different industries. Instructors may choose to discuss rent appropriability in class. Grok also faces competition from several major companies, including IBM (with its InfoSphere Streams technology) and Google (with its acquisition of Peak Stream). Another significant challenge is the fledgling company's need to establish a steady cash flow to support natural growth. Options that Hawkins might consider are selling out to a larger firm (acquisition), holding an initial public offering, securing private equity funding, or forming strategic alliances to procure much-needed resources.

## Suggested Questions

### *ANALYSIS: FOCUS ON EXTERNAL AND/OR INTERNAL ENVIRONMENTS*

1. What is Hierarchical Temporal Memory (HTM)? How does it work? What are its potential / most promising business applications?
2. What does the invention of HTM teach us about innovation?
3. What are Grok's key resources and capabilities?
4. (Advanced) Can Grok's resources and capabilities be a source of sustainable competitive advantage? Why or why not?

### *FORMULATION: FOCUS ON BUSINESS, CORPORATE, AND/OR GLOBAL STRATEGY*

5. What business model should Grok implement? Explain.
6. Based on the industrial life cycle model, what should Grok's strategic goals be at this stage of development?

## *IMPLEMENTATION: FOCUS ON RECOMMENDATIONS AND HOW TO EXECUTE THEM*

7. What should Jeff Hawkins do to finance future growth for Grok?
8. How should Hawkins structure the Grok organization to best achieve its strategic goals?

## *ANALYSIS: FOCUS ON EXTERNAL AND/OR INTERNAL ENVIRONMENTS*

1. What is Hierarchical Temporal Memory (HTM)? How does it work? What are its potential / most promising business applications?

Hierarchical Temporal Memory (HTM) is a machine-based learning model built on Hawkins' memory prediction theory of how brains work, which was first laid out in his 2004 book *On Intelligence* (for a diagram of the human brain, see [www.brainwaves.com/brain\\_diagram.html](http://www.brainwaves.com/brain_diagram.html)). HTM's way of addressing the key issue in building intelligent machines—knowledge representation—is fundamentally different from how AI approaches it. AI's way of tackling the problem is to build a huge database of knowledge about the world. HTM, on the other hand, works by feeding the system with sequences of spatial and temporal patterns and letting the system train and learn on its own. In the HTM model, when the computer recognizes something similar, it uses past information to predict what will happen and assign a probability to that predicted outcome. Case Exhibits 2–4 provide graphics depicting how HTM works; you may want to talk through these with your students if they are having difficulty understanding the technology. Alternatively, you may wish to show one of the videos listed under Additional Resources (#3–5), in which Hawkins explains his theory of the brain in his own words, to start off your class discussion.

HTM has many capabilities (see Case Exhibit 5) and can be used in a broad range of industries (see Case Exhibit 6). Any industry with critical needs for cognitive intelligent software is a good candidate. The most promising advantage of HTM is that it is not confined to data gathered through human senses. A multifaceted and diverse HTM sensory system, where powerful computing is combined with infrared, radar, or sonar technology, means HTM can perform tasks that human beings are physically incapable of doing.

2. What does the invention of HTM teach us about innovation?

The case tells us what it takes, first of all, to create a great invention, and second to transform that invention into a successful innovation. The role of the entrepreneur is highlighted in this case. Hawkins has been chasing his “brain theory” dream all his life, displaying great passion and commitment. He has pursued his dream in spite of being told by leading experts at Intel, MIT, and UC-Berkeley that what he wanted to do could not be done. Bringing an invention to market also needs a huge amount of financial backing. Hawkins' successful mobile computing ventures have given him the leverage to make his “brain theory” dream come true. Yet even his computing innovations were not immediately successful; Hawkins experienced several initial product failures before finding the right combination of design and technology for the market. Another lesson that can be drawn from Hawkins' story is the need to recognize and exploit your personal strengths, while building a trusted network of business partners with complementary abilities (in this case, Donna Dubinsky and her expertise in business management).

In the market-technology 2×2 matrix, HTM is clearly a new technology rather than an existing one. The market dimension is not as clear. HTM could be applied in existing markets such as real data analysis; it could also be used to create some new market (for example, through the integration of computing with a specialized sensory system) that does not currently exist. So it is an innovation that falls somewhere between “disruptive” and “radical.” This means Grok should keep a close eye on the development of HTM applications and the direction of its expansion into different markets. If it is truly a radical innovation and opens up new markets, Grok should continue to follow up with incremental changes to sustain its competitive advantage. If it is a disruptive innovation, Grok must still improve its technology on a continual basis to make sure it penetrates all potential market segments. Grok’s release of its second-generation HTM algorithm in 2011 is consistent with this approach, and suggests that future upgrades are likely.

### 3. What are Grok’s key resources and capabilities?

Grok’s tangible resources include the financial backing of Jeff Hawkins and Donna Dubinsky, in addition to a few other investors. Its geographical location is also a critical resource since Grok lies in the heart of Silicon Valley, arguably the most important technology cluster in the United States (see Case Exhibit 1 for a map of technology companies in Silicon Valley). Silicon Valley provides Grok with access to a great pool of talented people, as well as a large amount of future venture capital.

Grok’s primary intangible resource is its human capital. Jeff Hawkins is a legend in the computing industry, and his fame helps Grok significantly in terms of gaining recognition and building brand image. Based on Hawkins’ past successes, people are already speculating that Grok is going to be the “next big thing” to come out of Silicon Valley. Given his inventive capability, combined with his independent wealth and track record as a successful entrepreneur, Jeff Hawkins appears to be the most important intangible resource Grok has when it comes to developing a sustainable competitive advantage.

The company also has an amazing team of senior managers. These include Dileep George, whose breakthrough allowed the operationalization of Hawkins’ brain theory, and Donna Dubinsky, Hawkins’ long-time business partner at Palm Computing and Handspring. Named CEO in May 2012, Rami Branitzky brings more than 15 years of experience in the software industry, including multiple leadership positions within SAP AG, to the Grok team. Jointly, Grok’s leaders provide it with great managerial skills, a key resource to ensure the success of a young enterprise. Brief biographies of all of Grok’s senior managers and members of the board of directors are provided in Exhibit TN-1.

Another important intangible resource is Grok’s HTM technology, which appears to be superior to AI in solving complex problems. Grok can increase its intellectual property by continuing its commercialization efforts and expanding the network of developers working with the HTM platform. The company has increased its number of HTM-related patents to six in recent years, which further strengthens its intellectual property space.

### 4. (Advanced) Can Grok’s resources and capabilities be a source of sustainable competitive advantage? Why or why not?

Applying the VRIO framework (from Chapter 5), we can see that Grok’s tangible and intangible resources are valuable. The financial backing provided by Grok’s founders and other investors enables

the business to grow. The company's physical location provides access to both brain power and additional investment capital. Grok's human capital is perhaps the key to its success, as is the case in any technology-intensive industry. Jeff Hawkins' personal brand image helps Grok gain legitimacy and support from important stakeholders. The joint managerial skills of Hawkins and Dubinsky assure astute leadership. Meanwhile, the HTM technology and recent patents are the basis for Grok's existence.

Most of Grok's resources and capabilities are also rare. First, Jeff Hawkins' passion, commitment, and deep understanding of brain theory lead to the founding of Grok and continue to fuel the company's growth. He developed a theory of the brain where none previously existed, and has patents to protect his intellectual property. Second, his reputation as a successful, serial entrepreneur and his preexisting network of Silicon Valley investors can facilitate Grok's access to venture capital. This is also rare given the vast number of startups in Silicon Valley, against which Grok would otherwise have to compete for funds. The managerial knowledge of the Hawkins-Dubinsky team (working together for the third time) is another rare resource—few startups are fortunate enough to be led by entrepreneurs who have millions of dollars at their disposal and have already brought two ground-breaking innovations successfully to market. Thus, because Grok's resources are both valuable and rare, the company should have at least a temporary competitive advantage. See Exhibit TN-2.

The next question is whether these resources are costly to imitate. Intangible resources such as Hawkins' personal experience, his reputation, and his long time collaboration with Dubinsky, are almost impossible to imitate. It will also be difficult to reproduce the intellectual capital of Grok's leadership team. As for the technology itself, Grok's patents provide it with some degree of protection. However, it is likely that competitors can find substitutes for HTM through developing alternative algorithms that have the same effect (for example, in reverse-engineering). This implies that Grok should protect its intellectual property carefully, perhaps by building a "patent fence." Overall, Grok possesses hard-to-imitate resources that can be used as the basis for building a sustainable strategic competitive advantage.

### *FORMULATION: FOCUS ON BUSINESS, CORPORATE, AND GLOBAL STRATEGIES*

#### **5. What business model should Numenta implement? Explain.**

Grok's future depends on how it decides to leverage its resources and capabilities into a profitable business model. The company's initial business model—a proprietary platform and dual licensing structure—facilitated the rapid development of the NuPIC software by building a community of open-source developers who were granted access under a free research license. To support developers in their efforts, Grok's website featured multiple tools such as a forum, wikis, and a blog written by members of the Grok team. Users were encouraged to become active participants, share their work, report bugs, and contribute to forums. Grok also developed a Partner Program, a fee-based support initiative in which participants received a high level of consulting and technical support. Once a developer reached a point where commercial value was created, Grok provided a fee-based commercial license. Prior to the product's commercial release, Grok had attracted between 100 to 200 developers and had eight partner companies working with its HTM technology.

Grok released its second-generation software, based on newer HTM algorithms, for beta testing in 2011. In anticipation of this commercial release, the company ceased active maintenance of NuPIC and its related vision applications. Existing NuPIC users had the choice to either adopt the newer version (at the commercial rate), or continue using the legacy software without the benefit of Grok's support.

One business model that Hawkins is likely to consider is what Microsoft did with MS-DOS: licensing it non-exclusively for a small fee to all customers. This enabled Microsoft to make MS-DOS the standard operating system for personal computing. In this vein, Grok has already entered a number of strategic alliances with companies including EDSA Power Analytics (a software firm that analyzes electrical power systems), Lockheed Martin, DARPA, and Electronic Arts (developer and marketer of video games), as well as a variety of energy and automobile companies. Other applications are likely in the defense, aerospace, and health care sectors. The more widely dispersed and accepted the HTM technology becomes, the more likely it is to become the default standard for intelligent computing applications.

**6. Based on the industrial life cycle model, what should Grok's strategic goals be at this stage of development?**

Grok's HTM software is in the introduction stage, where firms invest in R&D to create a new product and form an initial customer base (early adopters). Only a few innovators are active in the market, and products are positioned based on features and performance as opposed to affordability. Prices tend to be high to cover the expenses associated with R&D, small-scale production, and initial product launch.

Grok's main strategic objectives at this stage of development should be to achieve market acceptance and seed future growth. To accomplish this, Grok will need to build new capabilities in marketing as well as secure additional sources of funding. Key activities include educating potential customers about the product's intended benefits, finding distribution channels and complementary assets, and continuing to perfect the new technology. Performing such tasks successfully may enable Grok's HTM software to emerge as the dominant design as the industry matures into the growth phase.

**IMPLEMENTATION: FOCUS ON RECOMMENDATIONS  
AND HOW TO IMPLEMENT THEM**

**7. What should Jeff Hawkins do to finance future growth for Numenta and its HTM technology?**

Although both Hawkins and Dubinsky are independently wealthy, they cannot fund Grok's activities in perpetuity. To grow, Grok needs to create a reliable cash flow. Likely options include an IPO or an acquisition by a larger firm (such as IBM). In both cases, Hawkins would likely lose direct control over the technology and the firm he founded.

Strategic acquisition can be attractive to entrepreneurs who seek immediate liquidity. In the case of an IPO, CEOs and other early investors may not be able to sell immediately, and much can happen—both good and bad—before the lock-up period on their shares expires. Selling the company enables them to realize its value and exit the business more quickly. Another problem with IPOs is the cyclical feature of the IPO markets; the optimal window for a public offering may not be open when the



company is ready. Acquirers, on the other hand, are more interested in the expected synergies created by combining the two companies and may see unique value independent of market conditions.

Nevertheless, an IPO may prove to be a better option for Hawkins and his management team. In a strategic acquisition, one of two outcomes will generally occur. In the first case, the entrepreneur is required to stay on well after the transaction, with his compensation closely tied to the ongoing performance of the firm. But the control often lies in the acquiring firm, restricting the entrepreneur's ability to manage the company. This was what happened to Hawkins when he sold Palm. If we humans truly learn from past experience as described in Hawkins' memory prediction framework, we would expect to see Hawkins avoid a replay of this potential scenario. In the second instance, the entrepreneur immediately receives cash or unrestricted stock for the full value of the ownership interest, but does not have a continuing role or direct financial interest in his company's future growth. However, Grok is Hawkins' "baby," the culmination of his lifetime pursuit of a theory of how brains work, and he is unlikely to want to leave. Hawkins may also choose an IPO in consideration of Grok's employees, since strategic buyers often cut costs by eliminating duplicate departments and functions.

Now that the stock market is slowly picking up, especially in the technology sector, a few years from now may be a good time for Grok to go public. With the independent wealth of its initial investors such as Hawkins, Dubinsky, and others, Grok should be able to wait for optimal timing. Grok's managers clearly are not interested in retiring since they have a great passion for HTM and enjoy working together as a team. An IPO would provide them with the necessary resources to continue building and extending the Grok brand.

## **8. How should Hawkins structure the Grok organization to best achieve its strategic goals?**

With the shift toward commercialization, Grok has started to transition from a simple structure toward a functional structure. In firms with a simple structure, the founders tend to make all the important strategic decisions and run the day-to-day operations. The organization is relatively flat in nature, with a low degree of formalization and specialization.

In a functional structure, employees are grouped into distinct functional areas based on domain expertise. The functional areas generally correspond to stages in the company value chain such as R&D, engineering and manufacturing, marketing and sales, and support areas such as human resources, finance, and accounting. The head of each functional area reports to the CEO, who coordinates and integrates the work across functions. Still relatively flat in structure, functional configurations allow for a higher degree of specialization and greater division of labor, which is linked to higher productivity. Communication flows between the CEO and the functional units fluidly in both directions.

Please refer to Exhibit TN-1 for a list of Grok's senior management team and board of directors. Evidence that Grok is starting to transition to a functional structure include the appointment of Rami Branitzky (an outsider) as CEO in May 2012, with Donna Dubinsky stepping aside but remaining active as chair of the board of directors. More recently, Grok has also hired Sbutai Ahmad as VP of Engineering and Craig Vaughan as VP of Marketing and Product Management. Another sign of transition is that the company now has a five-member board of directors, including Hawkins and Dubinsky and three outsiders.

## Case Updates

Grok underwent a leadership change subsequent to the writing of this case. Rami Branitzky is no longer with the company, and Donna Dubinsky has resumed her role as CEO while remaining board chair. In addition, Grok has added two new members to its senior management team: Subutai Ahmad as VP of Engineering and Craig Vaughan as VP of Marketing and Product Management.

As part of its commercialization process, Grok has also formed a board of directors consisting of Donna Dubinsky, Jeff Hawkins, Ed Colligan, Mike Farmwald, and Harry Saal. Brief biographies of all senior managers and board members are provided in Exhibit TN-1.

## Additional Resources

1. For additional reading, see Jeff Hawkins' book with Sandra Blakeslee (2004), *On Intelligence: How a New Understanding of the Brain Will Lead to the Creation of Truly Intelligent Machines* (New York: Owl Books).
2. <http://ecorner.stanford.edu/authorMaterialInfo.html?mid=2217> (~57 min)

Stanford's University's Entrepreneurship Corner, Entrepreneurial Thought Leader Lecture: *Inside the Mind of a Reluctant Entrepreneur*. "Numenta's Jeff Hawkins, a frequent company founder, inventor, and product designer for Palm and Handspring, highlights lessons learned during his tenure in technology. He also confesses that these accomplishments were mere way stations in his 30-year passionate pursuit of neuroscience." Specific video segments are listed in the following for your convenience.

*The Twenty-Year Plan*. (3:16)

*The History of Palm and the Part-time Entrepreneur*. (06:07)

*An Entrepreneur's Take on the Non-Profit*. (01:57)

*Effective Choices, Not Longer Days*. (02:01)

*Forgo the NDA: Find Support Where You Can*. (02:38)

*Case Studies of Failure*. (05:28)

*Palm's Approach to Elegant Design*. (06:16)

3. [http://www.ted.com/talks/lang/eng/jeff\\_hawkins\\_on\\_how\\_brain\\_science\\_will\\_change\\_computing.html](http://www.ted.com/talks/lang/eng/jeff_hawkins_on_how_brain_science_will_change_computing.html) (20:16 min). TED talk: *Jeff Hawkins on How Brain Science Will Change Computing*. "Treo creator Jeff Hawkins urges us to take a new look at the brain—to see it not as a fast processor, but as a memory system that stores and plays back experiences to help us predict, intelligently, what will happen next."
4. <http://www.youtube.com/watch?v=G6CVj5IQkzk> (22:09 min). *Brain Science is about to Fundamentally Change Computing*. A brief talk on how Hawkins' brain theory works.



5. *Jeff Hawkins on Artificial Intelligence*. (60 min total). This video series provides a more detailed discussion of how HTM works. Jeff Hawkins also touches on the potential applications of HTM and a little bit on Numenta/Grok.

Part 1/5: <http://www.youtube.com/watch?v=oozFn2d45tg>. (09:47).

Part 2/5: <http://www.youtube.com/watch?v=pjpWISEil44>. (09:57).

Part 3/5: <http://www.youtube.com/watch?v=pngRexsrmGk>. (09:02).

Part 4/5: <http://www.youtube.com/watch?v=GpekuvG4JMg>. (06:38).

Part 5/5: <http://www.youtube.com/watch?v=FthvUpHzwfA>. (05:49).

Contact your local representative from McGraw-Hill Education (<http://shop.mheducation.com/store/paris/user/findltr.html>) for information about access to financial analysis spreadsheets.

## EXHIBIT TN-1 Grok's Top Management Team

**Donna Dubinsky, Co-founder, Chief Executive Officer, Board Chair**

Grok Co-founder and CEO Donna Dubinsky serves as Board Chair. Donna joined Jeff Hawkins in 1992 to become president and CEO of Palm, a position she held through Palm's acquisition by U.S. Robotics and subsequently 3Com Corporation. In 1998, Donna and Jeff co-founded Handspring, creator of the category-defining Treo smartphone. In October 2003, Handspring merged with Palm, where Dubinsky continued to serve on the board until early 2009. Previously, Donna spent 10 years at Apple Computer in a variety of sales, sales support, and logistics functions both at Apple and at Claris, Apple's software subsidiary.

Donna holds a B.A. from Yale University, and an M.B.A. from the Harvard Business School. She currently serves on the board of the Peninsula Open Space Trust, the Computer History Museum and Yale University.

**Jeff Hawkins, Co-founder, Director**

Jeff Hawkins is an engineer, serial entrepreneur, scientist, inventor, and author. He was a founder of two mobile computing companies, Palm and Handspring, and was the architect of many computing products such as the PalmPilot and Treo smartphone. Throughout his life Jeff has also had a deep interest in neuroscience and theories of the neocortex. In 2002, he founded the Redwood Neuroscience Institute, a scientific institute focused on understanding how the neocortex processes information. The institute is now located at U.C. Berkeley. In 2004, he wrote the book *On Intelligence*, which describes progress on understanding the neocortex. In 2005, he co-founded Grok (formerly known as Numenta), a startup company building a technology based on neocortical theory. It is his hope that Grok will play a catalytic role in the emerging field of machine intelligence.

Jeff Hawkins earned his B.S. in electrical engineering from Cornell University in 1979. He was elected to the National Academy of Engineering in 2003.

**Sbutai Ahmad, VP of Engineering**

Subutai Ahmad brings experience across real-time systems, computer vision, and learning to his leadership of the Grok Engineering team. Prior to Grok, Subutai served as VP Engineering at YesVideo, Inc. From 1999 until 2005, he helped grow YesVideo from a three-person startup to a leader in automated digital media authoring. YesVideo's real-time video analysis systems have been deployed internationally

on a variety of platforms: Large-scale distributed clusters, retail minilabs, and consumer set-top DVD Recorders. In 1997, he co-founded ePlanet Interactive, a spin-off from Interval Research. ePlanet created the IntelPlay Me2Cam, the first computer vision product developed for consumers. Previously, Subutai served as a researcher at Interval Research.

Subutai holds a bachelor's degree in Computer Science from Cornell University, and a PhD in Computer Science (thesis on computational neuroscience models of visual attention) from the University of Illinois at Urbana-Champaign.

**Craig Vaughan, VP of Marketing and Product Management**

Craig brings 20 years of experience in a broad range of business roles across enterprise technology companies. Most recently, Craig held global leadership roles in marketing and sales at SAP—managing strategic marketing and sales programs, competitive programs and business development. Previously, Craig led product management and marketing at Moai Technologies and worked on multiple process/system integration projects for over five years at Accenture. He has also held roles in strategy consulting and venture capital, focusing on high-growth emerging companies.

Craig holds a Bachelor of Science degree in Business Administration from Cornell University and an MBA from the Wharton School at the University of Pennsylvania (with majors in Marketing and Finance).

**Ed Colligan, Director  
Former President & CEO, Palm, Inc.**

Ed's first big success was Radius, Inc. where he was part of building the Radius brand to be synonymous with graphics and graphics imaging at the outset of the desktop publishing revolution.

Ed was the first vice president of marketing for Palm where he helped develop the original PalmPilot and the Palm brand. Ed left Palm to found Handspring, where he and his partners created the forerunner of all future smartphones: the Handspring Treo. Ed drove the transaction that reunited Palm and Handspring into a single Palm again. As the CEO of Palm, Ed spearheaded the transformation that created the highly acclaimed WebOS platform and Palm Pre line of smartphones. Ed now spends his time investing in and mentoring entrepreneurs with the goal of helping establish the next generation of breakthrough products and brands.

Ed holds a bachelor's degree from the University of Oregon.

(continued)

## EXHIBIT TN-1 Grok's Top Management Team (continued)

**Mike Farmwald, Director**  
**General Partner, Skymoon Ventures**

Mike Farmwald is a successful serial entrepreneur. He has founded many companies with breakthrough technologies, including FTL—a super-computing company that merged with MIPs, Rambus—a developer of high-bandwidth interfaces for memories and other chips, Chromatic Research—a developer of media processors that was acquired by ATI Technologies, Epigram—a creator of advanced semiconductor home networking technology that was acquired by Broadcom, and Matrix Semiconductor—a creator of 3D integrated circuits.

Mike holds a BS degree in Mathematics from Purdue University and a PhD in Computer Science from Stanford University. He currently sits on the boards of Rambus (NASDAQ: RMBS). Mike is participating on the Grok board as an individual rather than as a representative of Skymoon Ventures.

**Harry Saal, Director**  
**Chairman of ZERO1, the Arts & Technology Network**

In 2002, Dr. Harry J. Saal was chosen by the U.S. Department of Justice to lead the Technical Committee charged with

monitoring and enforcing the Microsoft Antitrust case. He served as Chairman of the Committee through the May 2011 expiration of the judgment.

Harry Saal founded Nestar Systems, a pioneer in local area network systems, in 1978. In 1986, Harry became the founder and CEO of Network General Corporation, the first company wholly dedicated to the area of network diagnostics. From 1993 through 1995, Harry served as founding CEO and President of Smart Valley, Inc., a non-profit organization chartered to create a regional electronic community based on an advanced information infrastructure and the collective ability to use it.

Harry is active in philanthropy and community affairs, having served as Chairman of the Board of the Community Foundation Silicon Valley, the President of Cultural Initiatives Silicon Valley, and the Vice Chairman of the American Leadership Forum, Silicon Valley Chapter.

Harry holds a BA, MA, and PhD in Physics from Columbia University. Harry serves on the board of the American Institute of Mathematics, among others.

Source: <http://www.numenta.com/about.html>.

## EXHIBIT TN-2 A VRIO Analysis of Numenta

| Numenta's Resources and Capabilities<br>... are they? | Valuable<br>V | Rare<br>R | Costly to<br>Imitate<br>I | Organized to<br>capture value<br>O |
|---|---------------|-----------|---------------------------|------------------------------------|
| Capital   | •             |           |                           |                                    |
| Geographic location                                   | •             | •         |                           |                                    |
| Patents   | •             | •         | ?                         |                                    |
| HTM technology  | •             | •         | ?                         | •                                  |
| Jeff Hawkins' reputation                              | •             | •         | •                         | •                                  |
| Managerial experience                                 | •             | •         | •                         | •                                  |

## Endnotes

1. <https://www.groksolutions.com/index.html>.