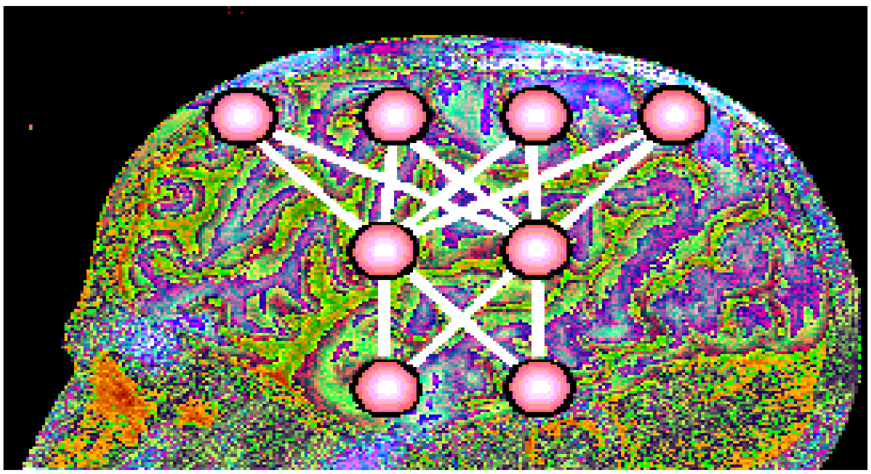
Artificial Neural Networks: The next intelligence

By Amit Khajanchi



"The computing world has a lot to gain from neural networks. Their ability to learn by example makes them very flexible and powerful. ..Perhaps the most exciting aspect of neural networks is the possibility that some day 'conscious' networks might be produced."[1]

- **Christos Stergiou and Dimitrios Siganos**, Department of Computing, Imperial College of London

Abstract

This paper is divided in two parts. Part one examines the relevance of Artificial Neural Networks (ANNs) for various business applications. The first section sets the stage for ANNs in the context of modern day business by discussing the evolution of businesses from Industrial Revolution to current Information Age to outline why business today are in critical need of technology that sifts through massive data. Next section introduces Artificial Neural Network technology as a favorable alternative to traditional analytics and informs the reader of the basic concept underlying the technology. Finally, third section screens through four different applications of ANNs to gain an insight into potential business opportunities that lie abound.

Part Two focuses on a commercial venture that leverages ANN. For this purpose, a case study of HNC Software, a technology company that patented fraud detection application using Artificial Neural Networks , is examined. The case will present company's profile, its competitive landscape, and various technology issues it encountered through its growth phase. Finally, the paper will end by asking a critical question that highlights the relevance of strategy in a technology venture.

Introduction

Modern day businesses face unique challenges that were nonexistent prior to the Industrial and Internet Revolution. Industrial revolution brought about the concept of economies of scale, mass production and standardization. Businesses competed on the grounds of operational efficiency and scale of production. As a result, successful organizations grew larger to accommodate these practices and faced an increasing amount of coordination costs to fulfill their services. Advances in communication technology such as telephone, television, fax and internet have greatly enhanced the organization's ability to coordinate through chains of geographically dispersed units, suppliers, and customers and enabled the large corporations to minimize coordination costs. As a result of those advances and improvements in transportation, businesses started competing on the grounds of timely delivery of products/services and customer satisfaction.

Today, greater means available for distribution, communication, and production facilities are not without their cost. What is at stake is the crucial element of business--customer relationship. In the old days, a business manager knew the customers inside and out and recommended products suited to their needs and preference on a timely fashion. However, with the advent of mass marketing, mass distribution, and mass production, business decision making (product planning, cross selling, pricing decisions) has become detached from a ***unique customer*** to fit the needs of an ***average potential customer***. The truth is, *the product that satisfies an average customer has a low customer satisfaction rate* because it is not optimized to fit a unique customer's needs and/or preferences. As a consequence, niche players who can accurately define their customer segment have a greater advantage over larger businesses that cannot.

Large enterprises strive to stay competitive by strategically utilizing modern day analytics to understand and to be closely in tune with the changing needs and preferences of their customers. Statistics (moving averages, ratio analysis, time series analysis, regression analysis) and computational science (linear programming, calculus, and simulation techniques) greatly enhance the businesses' ability to dissect the given data and organize it to create meaningful information to support decision making. However, all these methods require man power (1) to organize appropriate data; (2) to analyze meaningful information; and (3) to communicate useful knowledge. This process is time consuming and worse yet, "static" (meaning that the result of analysis is specific to the time frame of analysis). The Artificial Neural Networks approach provides an attractive alternative that enables large businesses to be adaptive to the changing needs and preferences for each customer segment.

Overview of Artificial Neural Networks (ANNs)

The concept of neural networks is modeled after biological sensory mechanisms where the neuron signals are transmitted to the brain and processed. This concept moves away from traditional statistical models where data are analyzed based upon holding everything else constant (ceteris paribus). The weakness in statistical models lies in their inability to model the changing relationships between variables (non-linear problem) and thus presents challenges in making a predictive analysis where the underlying relationships are not constant. A neural network overcomes this problem by being adaptive to real sets of data. Much like living organisms, a neural network gets training and learns the tricks of the trade by observation and re-adjusts its learning against new sets of data iteratively. Wen (2000)[2] states, "Artificial Neural Networks (ANNs) are an information processing technology pertaining to the area of machine learning in artificial intelligence. A neural network employs an adaptive structure that can be trained with application data to capture complex relationships between input and out variables."

Neural Network Architecture

The inherent power of neural networks lies in its ability to recognize the underlying relationship between input and output data. According to Nasir (2001),[3] "the prototypical use of neural networks is in structural pattern recognition." Through a preset learning algorithm and series of training iterations the network learns to recognize patterns in the data sets and assigns weights to each variable (nodes).

Neural network architecture employs multiple layers of nodes. A 'node' is where the data is converted into values between 0 and 1 using sigmoid transfer function in a network. Following figures illustrates this:

Figure 1: Processing algorithm of a node in a neural network (Wu 1994)[4]

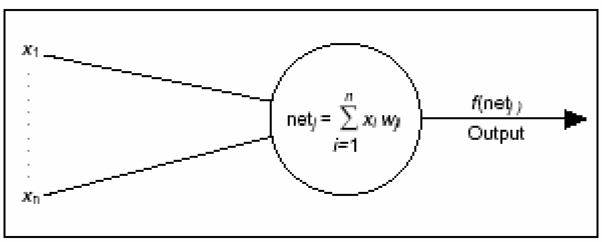
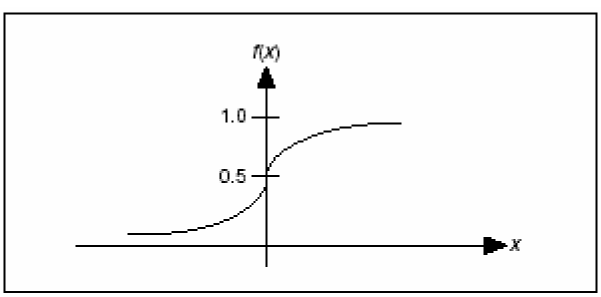


Figure 2: Graph of Sigmoid Transfer Function (Wu 1994)



Additional layer in neural network architecture models add complexity. For example, two layer architecture (Figure 3) will contain an input layer and an output layer; three layer architecture (Figure 4) will include a hidden layer in the middle (unobservable variables); and a more complex network will have fourth threshold (constraint) layer (Figure 5).

Figure 3: Two Layer Neural Network model (Chatterjee 2000)[5]

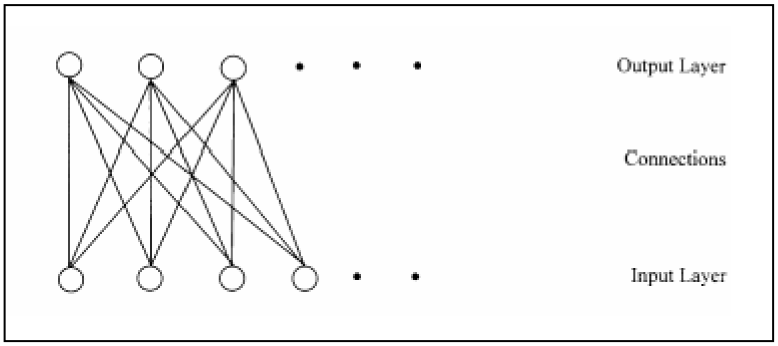


Figure 4: Three layer Neural Network model (Wu 1994)

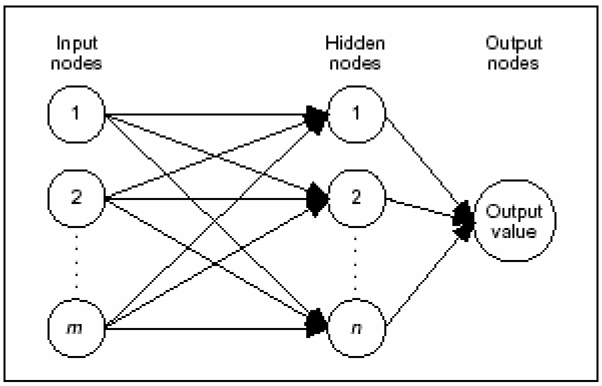
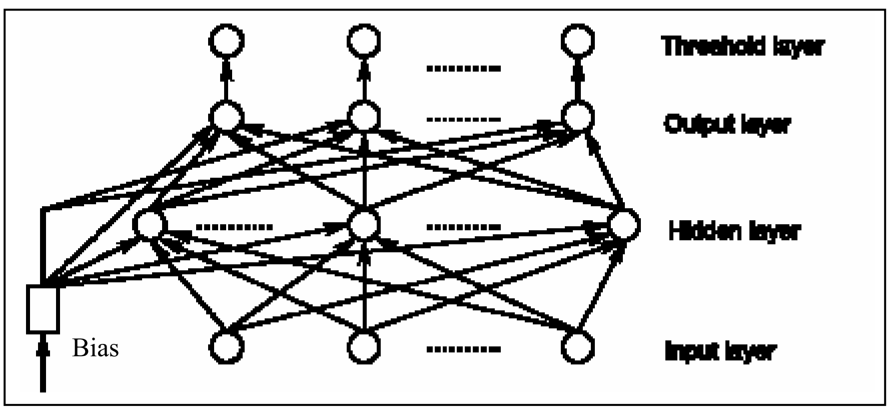


Figure 5: Four-layer feed-forward neural network model (Yue et al 2002)[6]



Learning Algorithm

The crucial part of neural network alchemy is in its ability to learn from series of iterations of input data (called the training period). The most basic algorithm that enables this is known as the delta rule. In 1962, Widrow[7] provided this first learning algorithm for 2 layer ANNs (a.k.a. perceptron). By 1986, with advances in computational technology and further academic work, Rumelhart, et al.,[8] suggested a more novel approach called the back propagation method that enabled learning for multilayered feed forward networks. Essentially, delta rule was insufficient for training networks with hidden layers that did not have direct inputs and outputs.

Back propagation provided a sounder training scheme for a network to incorporate multilayers of nodes in its design according to Wen (2002).

In essence, the back propagation algorithm consists of three general steps (Wu 2000):

1. compute outputs
2. compare outputs with the desired targets, and
3. adjust connections weights and parameters of the activation function(s) to remove as much output errors as possible.

Screening the Technology for Opportunity Recognition

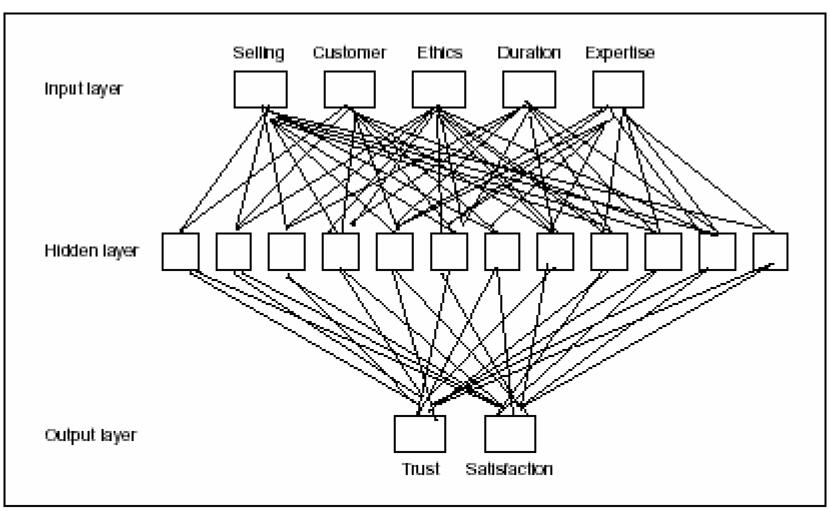
Artificial Neural Networks have a multitude of real world applications. They are well suited to dissect and analyze voluminous data and extract meaningful patterns and relationships. There has been much academic research done in this area and the results are promising. As Wray, et al., (1994)[9] mention, the advantages of neural networks over statistical models are (1) ANNs requires no predefined knowledge of underlying relationships between input and output variables; (2) ANNs' associative ability make them robust enough to tolerate missing and inaccurate data; and (3) ANNs' performance doesn't diminish with multi-collinearity problems, violations of set assumptions, high influence points, and transformation problems encountered in regression analysis.

In the following section four models are discussed that have been developed in research settings that have promising potential for real world applications.

Customer Relationship Model

Wray, et al., (1994) developed a neural network model to quantify the influence of qualitative attributes of the buyer-seller relationship in financial markets. The study focused on a customer's perception of a seller's sales orientation (seller-centric vs. customer-centric), expertise, and ethics as input variables. Additionally, a relationship duration variable was input as a mean to segment customer groups to predict satisfaction and trust scores (Figure 6).

Figure 6: Customer Relationship Model (Wray, et al., 1994)

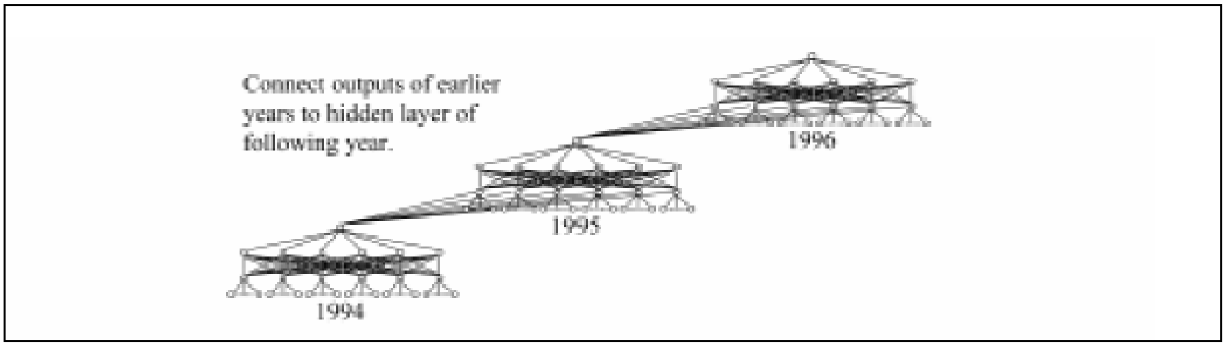


Wray concludes that neural networks may offer a superior solution to a wide range of marketing prediction problems. "The technique has been used in direct marketing to develop profile based on customer characteristic of most profitable customer."[10]

Bankruptcy Prediction Model

Nasir, et al., (2001) in his paper shows results of how accurately the neural network he trained was able to predict bankruptcy in corporations. He constructed a neural network consisting of 58 financial variables for 3 years plus 4 economic and political variables – thus making the total of 178 input variables. Financial variables were taken from Balance Sheets, Income Statement, Cash flow Statement, Financial Summary and Key Financial Ratio.

Figure 7: Bankruptcy Model - time neural network architecture Nasir (2001)



The network was trained using 2,500 profiles of a company, over 280,000 iterations. The network was able to predict bankruptcy with 85% accuracy for test data under stringent classification criteria. As the classification criteria were relaxed, the model exhibited 95% level accuracy.[11]

Inventory Management Model

Bansal, et al., (1998)[12] trained a neural network that would forecast optimal days of inventory the studied pharmacy (referred to as *Retailcorp*) needed to keep in order to minimize occurrence of stock outs (which translated to dissatisfied customer and loss of sale). The network's goal was to minimize stock outs (numbers and days of supply) for each item in the inventory. Two years' sales data for each item was input as a parameter. The network showed a significant improvement over previous inventory policy cutting the average days of supply in half. According to Bansal, "by deploying this neural network based model, the inventory at Retailcorp consisting of over a billion dollars worth of drugs can be reduced by 50% to about one-half billion dollars while maintaining the original customer satisfaction level (95% availability level)."[13]

As seen by this study, Retailcorp can generate a half billion dollar savings by deploying this new approach. (A simple DCF calculation assuming that the discount rate is 10% and there is no growth; savings of $50 million/year in financing cost for $500 million worth of inventory forever gives, $50 million/10% or $500 million.)

Financial Market Model

Chattejee (2000) postulates ANNs with genetic learning algorithms to be well suited to predict financial markets' behavior. Unlike the traditional statistical models, neural networks are better suited to model non-tangible factors such as beliefs, actions, and complex interactions of traders, hedgers, arbitrators and the Federal Reserve Board which play a significant role in influencing financial markets. Chatterjee describes the power of genetic algorithm:

> *While the search is relatively efficient, the genetic approach is not perfect. A genetic algorithm is not guaranteed to find the optimal solution.* ***However***, *it often comes close by finding acceptable alternatives in a relatively short period of time. The algorithm basically collapses the search space and possible solutions, while it continues testing sub-combinations.*[14]

Many financial institutions see the value of ANNs as a supporting mechanism for financial analysts and are actively investing in this arena. The following are examples:

Chase Lincoln First Bank	The ANN that evolved over a period of five years produces a customized plan that incorporates expertise in the areas of investment planning, debt planning, disability insurance planning, budget recommendation, income tax planning and savings planning for major financial goals.
Paine Webber	Paine Webber developed a system to provide its traders with real-time hedging advice on trades and positions. In 2000, the project was at a testing phase.
Security Pacific National Bank	SPNB actively seeks strategic advantages through technology by forming an artificial intelligence unit in 1986 to provide advice and support for AI application in the corporation. Their current applications include for foreign exchange trading, real estate appraisal, and loans.

Table 1: ***Source Chatterjee (2000)***

Commercializing Artificial Neural Networks Technology

In this section, HNC Software is examined as a case study of a technology company that leverages Artificial Neural Networks. We will examine the company's profile, its competitive landscape, and its technology issues, and then discuss its acquisition by Fair Isaac.

Company Profile – HNC Software

HNC Software, now part of Fair Isaac, is located in San Diego.

Background

Two TRW's Neuro-computing Research and Development program veterans, Robert Hecht-Nielsen and Todd Gutschow, found Hecht-Nielsen Neuro-computer Corporation (HNC) in 1986. The company was initially conceived as a consultancy that trained government personnel in developing neural network software. Same year another TRW veteran Robert North joined the firm to be CEO of this enterprise.[15]

In 1990, the company redirected its corporate vision to developing commercial software applications for businesses. In the same year, the company developed Retail Inventory management and Fraud detection software. The company was officially renamed as HNC Software in 1994. In the meantime, the company pruned its expertise and rapidly grew its business as a key player in the fraud detection domain and went public in 1995. At this point, Falcon credit card fraud detection system accounted for 85% of it annual sales.[16]

Growth Years

Success in software business and the need to expand its market in order to sustain growth led HNC to acquire other software technology companies. The following is the list of acquisition and spin-offs that ensured until the year 2002's acquisition of HNC Software by Fair Isaac.

Year	Company / Comment	Expertise in Product / Services
1996	**Risk Data**	Workers' compensation claim software analysis
	Retek Distribution	Retail Inventory Management Software
1998	**Bedford Associates**	Fraud management software for Telecommunication
1999	*E-commerce Division forms. Markets debit and credit card protection for internet.* *HNC software Spun-off Retek Retail Inventory Management Software division.*	
2000	*Robert North steps down, COO John Mutch appointed as his successor.*	
2001	**Brokat Technologies**	Blaze Advisor unit
	Chordiant Software	Marketing Service Provider business unit
2002	*HNC Software acquired by Fair Isaac*	

Table 2: ***Source Hoovers – incomplete reference***

Business Model

HNC Software's revenue is $227 million in the Fiscal Year of 2001 – 2002. Approximately 75% of its revenue comes from licensing and maintenance fee, and the rest 25% is generated through services (consulting, implementation, and training). In terms of their product line, HNC Software is leading provider of high-end analytic and decision management software.

Their portfolios of software include: HNC Efficiency Suite (Automation and management of business decisions), HNC Opportunity Suite (Optimization of marketing and customer relations) and HNC Risk Suite (Risk analysis and management). HNC's competitive strength lies in mainly in their expertise in neural networks, context vectors, rules engines and Critical Action Platform technology that underlie all its software technology.

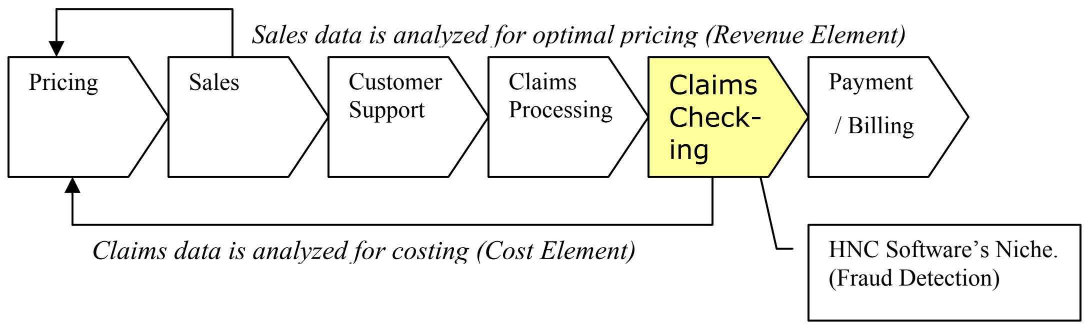
HNC holds patent no. 5,819,226 that was the basis of their Falcon fraud detection system they first developed. Their core business expertise lies in fraud detection technology that leverages the ANNs covered in this patent; Falcon Check (a checking account fraud detection solution) and VeriComp (a worker's compensation claims fraud detection system) are both software that are covered under their patent.

HNC Software caters to variety of industries including telecommunication, banking, insurance and medical industry. The common trait in all these industries is that they are highly regulated and have complex claim processing rules. The fraud detection technology HNC offers enables the players in this industry to minimize and manage their exposure to risk associated with fraudulent claims and default in payment.

Competitive Landscape

In order to understand the competitive landscape of HNC Software it is necessary to understand the niche market HNC Software occupies. Its technology and patent cover a very specific area of expertise in claims processing function. Because claims processing activity is a common practice in insurance, healthcare, banking, and telecommunication Industry, HNC Software can diversify its service offering to cover each of these Industries. The figure below illustrates the flow of activities that takes place in general claims processing activity.

Figure 1: Value Chain of generic claims processing activity



Taking an Automobile Insurance as an example: (1) Insurance contract is priced according to customer type and expected cost of servicing the insurance, (2) sales is generated, (3) customer gets into an accident and calls customer support, (4) claim processing starts, (5) the claim amount and terms of the contract is checked and verified, and finally, (6) payment is mailed to the customer. After a few runs, the whole process is analyzed to find the actual cost of servicing while sales data is analyzed for optimal pricing that would entice a customer into signing the contract. The price that will yield the maximum profit is applied to each type of contract. Although for each industry and product the nuance will be slightly different, this is the basic structure of claims processing.

A variety of technology and services are used to complete this activity. First, credit reports are needed to categorize the customer, sales data needs to be efficiently and intelligently collected to find price elasticity and trends, claims processing activity can be automated using rules-based engines, claims checking utilizes any anomaly in claims to detect fraudulent claims or over billing and finally, payout is recorded in the system. On top of different applications, the whole system uses massive data that needs to be stored and manipulated for further analytics. Thus, what this translates to is that there is compatibility of software and networking issues that need to be resolved to operate this process efficiently.

What we see in claims processing space is the formation of technology alliances; emergence of niche players for specific Industry vertical; and acquisition and vertical integration of software companies to resolve compatibility issues and to create barriers to entry for competitors. The table below lists the players in each activity space.

Technology	**Business Process**	**Company**	**Target Market(s) / Industry(ies)**
Credit Scoring	Pricing, Sales	***Fair Isaac***	Consumer Credit, Insurance, Banking, Telecommunication
Database Management	Data Storage and Manipulation	***Oracle*** ***Fair Isaac***	Enterprise Market (All Segments) Insurance, Banking, Telecommunication.

Customer Management	Pricing, Sales, Customer Support	***Siebel Systems*** ***Fair Isaac***	Medium-Enterprise Market (All Segment) Insurance, Banking, Telecommunication
Fraud Detection	**Claims Checking**	***Nestor***	**Consumer Credit (direct Competitor)**
Workers Compensation	Claims Checking, Payment, Billing	***PeopleSoft***	Enterprise Market (All Segment)
Online Credit Reporting	Payment, Billing	***Experian***	Consumer Credit

Table 3: List of competitors for each activity

Technology issues and strategies

Like any technology company, the basis of competitive advantage at least for initial growth years comes from development of commercial technology. However, there can be costly obstacles such as patent or other litigation.

Patent Litigation: Nestor vs. HNC Software[17]

In 1998, Nestor Inc. filed a lawsuit against HNC Software claiming that HNC Software infringed upon Nestor patent no. 4,706,604 and was in violation of anti-trust laws. To counter the suit, HNC Software filed suit in 1999 that essentially claimed that Nestor was infringing on HNC's patent no. 5,819,226. In January of 2000, Nestor dropped the charges against infringement but continued to litigate the anti-competitive suit.[18]

Acquisition and cross licensing

Unlike biotechnology or consumer goods, the software industry has low distribution and manufacturing cost. The marginal cost of downloading software over the internet or burning a CD is close to nothing. The bulk of the cost lies in three major areas: licensing costs, arising from the usage of other proprietary technology; research and development costs to build bug fixes, patches and next generation applications; and finally, sales and marketing cost, because a lot of educational material and brand presence is necessary to drive revenues.

One way to mitigate risks arising from each of these expense items is cross licensing. Companies like IBM keep portfolios of patents to mitigate these licensing costs. For a niche player, acquisition of complimentary product line will lower the technology risk: (1) because the company will be less dependent on patent outside the firm and (2) the products suite will be tightly integrated and will create customer lock-ins.

In terms of its acquisition strategy, HNC focused on acquiring companies whose product could be improved by neural network based solutions, for example, Retek's Inventory Retail Management System. The primary value proposition for acquisition was the brand recognition, list of partners and customer portfolio it would acquire. HNC took a horizontal integration strategy in order to expand the target market size. It envisioned itself the trusted leader in fraud detection for telecom, government, insurance, banking, and healthcare. However, as a result of these acquisitions, HNC's performance suffered making it vulnerable for a takeover by Fair Isaac in 2002.

Acquisition by Fair Isaac

Fair Isaac is the leading provider of predictive modeling solutions, marketing and account management systems, and decision support systems using proprietary decision engines and automated strategy development systems.[19] FICO scores, a proprietary score characterization of consumer's creditworthiness, is marketed by Fair Isaac and is commonly used in standard loan applications. At the end of 2001, Fair Isaac's revenue was approximately $300 million.

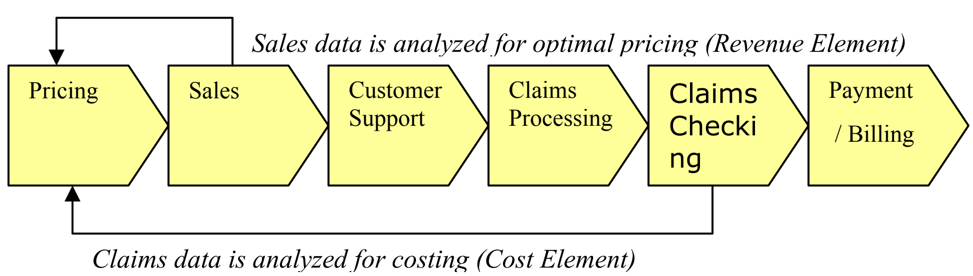
Over the years, Fair Isaac has solidified its industry position in the insurance and consumer credit industry through its acquisition and partnerships. By focusing its efforts in consumer behavior analysis based on statistical models, it develops decision support systems that can optimize, manage, automate, and support claims processing activity.

Year	Company / Comment	Expertise in Product / Services
1992	**DynaMark**	Consumer database management company
1995	**Total Systems Services**	**Partnered** to develop Market relational database with Total Systems Services (a Credit Card Processor).
1997	**Risk Management Technologies**	Risk Management Software
1998	**Net Earnings & Experian Information Services**	**Partnered** to develop Web based credit report provider, CreditFYI.
2000	**Acquired smaller CRMs**	

Table 4: Source *Hoovers – incomplete citation*

HNC Software fit the mold for Fair Isaac in that it held a superior technology using neural networks that complimented the line of products Fair Isaac had. By using its claims optimization suite (includes database, customer relationship management, risk management, and FICO score formulation) and combining it with fraud detection technology of HNC, Fair Isaac could further help business minimize risk and lower cost.

Figure 2: Fair Isaac dominates at all levels for Claims Processing – Insurance & Banking



Questions and issues

Although horizontal strategy that HNC employed led to its eventual take over, can the success of Fair Isaac simply be attributed to its vertical strategy? By focusing on niche market, Fair Isaac constraints its target market to be smaller. Now that Fair Isaac covers an entire value chain of claims processing function, what opportunities lie ahead for Fair Isaac to grow and add value to its customer? What is the next successful growth strategy for a technology venture that has reached its maturity?

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