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LEVERAGING INFORMATION TECHNOLOGY EXPERTISE TO DELIVER IN EMERGING MICRO-MANUFACTURING AND NANO-TECHNOLOGY MARKETS

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ABSTRACT

The drive for miniaturization has resulted in the mushrooming of a large number of start-up firms in the fields of micro-manufacturing and nano-technology. Even as these firms drive home their strategic technological expertise to rake in profits and expand in their countries of origin and globally, the need for a comprehensive information technology strategy to connect with customers and within the firm is increasingly felt. While these firms may have an internal IT department to begin with, an ever increasing customer base calls for a larger firm with proven prior expertise in implementing solutions on a larger scale. Further, it is seen that the IT needs of these firms are significantly different from traditional heavy manufacturing firms, where production is on a mass scale. It is here that EDS can leverage its proven success strategies in delivering successful solutions that enable these firms to grow in size and profitability.

Keywords: information technology, micro-manufacturing, nanotechnology

1. INTRODUCTION

The first decade of the 21st century is witnessing a greater-than-ever push for the production of small parts, in a wide range of applications ranging from medical, defense and electronics to aerospace, automotive and communications. As a response to these needs, government funding in academic research in the fields of micro-manufacturing and nano-technology has consistently risen in comparision to traditional disciplines globally, resulting in a large number of new patentable processes and technologies. Fuelled by this incredible success in research, several new startup firms have come up, some locally and other globally, very often by engineers and technocrats who have had hands-on experience in developing miniaturized products and nano-scale processes. For instance, Microlution, Inc. is a successful startup venture based in Chicago, IL, set up by two budding graduates of the University of Illinois at Urbana-Champaign and providng advanced manufacturing solutions for the production of small, precision machined components [1]. Likewise, NanoInk, Inc. is an emerging nanotechnology firm headquartered in Skokie, IL, with a MEMS (micro-electro mechanical systems) fabrication facility in Campbell, CA. A spin-off of Northwestern University, NanoInk specializes in nanometer-scale manufacturing and applications development for the life science and semiconductor industries [2]. Many firms have grown out of their single site offices to build agencies worldwide that cater to sales, marketing, fabrication and R&D, viz. Klocke Nanotechnik, which has its headquarters in Aachen, Germany, is now based globally in 8 countries including India, Japan and China [3]. It is also noteworthy to mention in this context that many large global conglomerates have also undertaken long-term research projects in micro- and nano-technology within the R&D wings of their firms. For instance, IBM's research facility in Zurich, Intel USA and Hewlett-Packard have been exploring issues relating to dip-pin nanolithography, nano-thermal processing, etc.

resulting in patents [4-5]. However, such firms have not been considered as part of this study as this defeats the purpose of this paper in reaching out to firms which are primarily entrepreneurial start-ups specializing only in micro- and nano-technology products. An ever-growing business incorporating newer and newer products, coupled with increasing globalization, calls for reaching out to the largest customer base, alongwith maintaining internal intra-firm communication, which is best achieved by an integrated IT strategy. This paper explores some of these aspects, including how these firms have diverging business needs as opposed to their traditional heavy manufacturing counterparts, and how these needs can be addressed best by an experienced and global IT firm like EDS.

2. THE CHALLENGE POSED BY THE NEW MINIATUARIZATION PARADIGM

Traditional manufacturing technology, which has largely been driven by men, materials and machines, relies on mass production to garner profits. While traditional manufacturing can never be done away with, for we will never drive in micro-cars or fly on micro-aeroplanes, yet, the internal components which form part of these larger structures keep getting smaller and smaller, while delivering higher horse power, efficiency, increased flexibility, portability and longer service life. Manufacture of these specialized internal components calls for the adoption of the latest micro-machine tools, stereolithographic processes, micro-molding equipment, etc. These specialized equipment again are often available only with start up firms, who own the patents to these processes. As such, the success of these firms in delivering these components, often determines the success of the latest product launches of larger firms, who have incorporated these firms in their supply chain. Since micro-manufacturing and nanotechnology solutions are still in their infancy, mass manufacture is still an ideal in this field, and parts are often customized to client needs thereby incurring heavy costs per part. To render micro/meso-scale parts and devices to be commercially viable products, issues related to parallel processing, data transfer, networking, and reconfigurability must be addressed [6].

2.1 Case Study

To understand the key challenges posed by the new miniaturization paradigm, ten (10) traditional heavy manufacturing firms were hand-picked and contrasted with the needs of ten (10) other micro-manufacturing and nano-technology firms. The selection of these firms was done so as to cover a wide range of markets reached out by manufacturing firms, and also to cover different geographical locations across all continents. A set of quantifiable parameters were used to study the current portfolio of the firm, and to use this portfolio to assess their need for a successful IT strategy. These parameters were identified as: i) world headquarters, ii) number of production sites/countries with offices, iii) workforce size, iv) core competency, v) diversification products, vi) inception year, vii) revenues for 2007-08 (or latest available figure) in US $ viii) fortune 500 rank, ix) profits, x) customer base, xi) web-page customization based on region/language/country.

Each individual parameter was then used to make inferences about the needs of these firms for driving home the competitive advantage through the use of IT and IT enabled services. For instance, the number of production sites in different countries was used to identify the markets the firm is reaching directly, and hence, this might call for building country/language based customization for the firm's online advertisement campaigns in these countries. Likewise, the year of inception gives an idea about the firm's legacy experience which can be archived in a suitable digital format for use by the employees of the firm. The revenue and profits was used to infer the financial strength of the firm and its growth, and a comparison of the results between the heavy manufacturing sector and the micro- and nano-technology sectors tells us about the extent of financial management and accounting needs of these firms, which may further be enabled by suitable enterprise applications which can handle overall operations of individual employees, departments, projects and individual offices. Likewise, a firm with a larger number of diversified products will require integration on various fronts, including any mergers and acquisitions which may have resulted in the current diversification. A comparison of

the current web-page customization and the geographical extent of the firm's customer base also throws light on the needs of the firm for enabling language support on the firm's web portals.

The results of the study on traditional heavy manufacturing firms are outlined in Table 1, while the results of the study on micro- and nano-manufacturing firms are shown in Table 2. The data collected here is primarily from the web-sites of these firms [1-3, 7-25], where balance sheets, company profile, and other links provide the majority of the figures, which were also tallied with other reliable sources on the internet such as Forbes' magazine, online newspapers, and Wikipedia to ensure accuracy of data.

Table 1. Portfolio of selected traditional heavy manufacturing firms

Firm	Head-quarters	Production sites/ offices	Workforce size	Core competency	Diversification Products	Inception	Revenue (in USD billions)	Profits (in USD billions)	Fortune 500 rank	Customer base	Web-page Customiz-ation
Caterpillar, Inc.	Peoria, IL	480 in 23 countries	97, 444	Construction and mining equipment	diesel and natural gas engines; industrial gas turbines; Financial services	1925	44.96	3.54	50	200 countries	Language support (English, French, Spanish); country customized
John Deere	Moline, IL	27 countries	52, 022	agricultural equipment; forestry equipment	equipment financing	1837	24.08	1.82	102	Global	Country customized multiple language support
General Motors	Detroit, MI	35 countries	284, 000	Automotive Engines	Financial services	1908	181.22	-38.72	4	Global	Continent customized
Ford Motor Co.	Dearborn, MI	10+ countries	245, 000	Automotive	Automotive finance; Vehicle leasing; Vehicle service	1903	172.46	-2.72	7	Global	Country customized English, Spanish support
Lockheed Martin	Bethesda, MD	U.S only	140, 000	Aerospace mfg.	ATC systems; Ballistic missiles; Transport aircraft;	1912	41.86	3.03	57	32 countries	None
Arcelor Mittal	Luxembourg City, Luxembourg	60 + countries	320, 000	Steel	Construction	1976	105.2	10.36	137	Global	None
Nucor	Charlotte, NC	53 in US, 1 in Trinidad	20, 000	Steel	--	1897	16.6	1.47	151	North America	None
Hero Honda	New Delhi, India	India only	N.A.	Motorcycles Scooters	--	1984	2.87	0.22	--	Indian sub-continent; parts of Africa	None

Daimler AG	Sttutgart, Germany	33 countries	273, 382	Automotive	--	1998	145.11	5.88	38 (global)	Global	English, Deutsch support;
Renault	Boulogne-Billancourt, France	118 countries	130, 179	Automotive	--	1899	54.79	3.78	128 (global)	Global	Country customized ; Multiple language support

N.A. – Not applicable

Table 2. Portfolio of selected micro-manufacturing and nano-technology firms

Firm	Head-quarters	Production sites/ offices	Workforce size	Core competency	Diversification Products	Inception	Revenue (in USD billions)	Profits (in USD billions)	Fortune 500 rank	Customer base	Web-page Customization
GF Agie Charmilles	Losone, Switzerland	129 in 12 countries	12, 986	EDM; Machining centers; Spindles; Consumables Parts and services	--	2007	1.07	0.069	--	12 countries	Multiple language support; country customized
Microlution, Inc.	Chicago, IL	U.S. only	<500	CNC Micro-milling center	--	2006	N.A	N.A.	--	United States	None
Fanuc	Mt. Fuji, Japan	Global sales and service offices	4695	Robotic and CNC systems Servo motors Nano machines	--	1956	3.77	1.61	--	Global	Country customized; Japanese, English support
Makino	Tokyo, Japan	13 countries	3, 000	Precision machine tool manufacturer	--	1937	N.A	N.A	--	Global	None
Smaltec Intl., LLC	Lisle, IL	U.S only	N.A	Micro-EDM Protoyping	--	2003	N.A	N.A	--	United States	None
Nanoink, Inc.	Skokie, IL	U.S only	N.A.	Dip pen nano-lithography	--	2001	N.A	N.A	--	United States	None
Stratasys	Eden Prairie, MN	4 countries	360	Precision rapid prototyping solutions	--	1989	0.112	0.014	--	Global	None

Nanometrics, Inc.	Milpitas, CA	9 countries	523	Nano scale electronics mfg.	--	1975	0.146	-0.004	--	Global	None
Klocke Nanotechnik	Aachen, Germany	8 countries	N.A	Nano-technology	--	1992	N.A.	N.A	--	Global	None
Microsystems (UK) Ltd.	Warrington, UK	U.K. only	N.A	Micro- and nano-technology	--	N.A	N.A	N.A	--	European Union	6 European languages supported

N.A. – Not applicable

3. INFERENCES FROM STUDY

A detailed study of Tables 1 and 2 yields important insights into some key differences between the traditional manufacturing firms and the emerging micro-manufacturing and nano-technology firms. Quite clearly, most traditional firms included in this study have a long legacy of providing quality products to customers and some of them have even been in existence since the 19th century. Since the micro- and nano-sciences evolved only in the later half of the 20th century, the founding of these firms was done only recently. As such, while most of the heavy manufacturing firms have succeeded in establishing a large customer base often spanning all the major continents in the world, as in the case of Caterpillar, Inc. which mentions a customer base of 200 countries on its portals, most micro- and nano-technology firms are still working their way up in their countries of origin, as in the cases of Microlution, Inc., Smaltec International, LLC, and Nanoink. However, it is interesting to note that some of these micro- and nano-technology firms have grown out of their home countries to sell their products and even establish production sites outside their countries of origin, as with Makino, Fanuc, Charmilles, Klocke Nanotechnik and Nanometric, Inc. Fanuc and Makino even have a history that dates back to the World War II era and immediately after. Of course, it is also important to mention that these two firms were then primarily concerned with development of heavy machine tools and industrial robotics products, and were able to move into the micro- and nano-technology sectors thanks to their expertise at precision manufacturing. Taking a look at the workforce sizes of these firms, only Fanuc (4695), Makino (3000) and Charmilles (12986) have sizeable workforce sizes, which still is way behind the employment provided by the heavy manufacturing firms such as Arcelor Mittal (320, 000), General Motors (284, 000) and Ford (245, 000). This is well explained by the fact that while these emerging firms have a smaller product base, the larger firms are well diversified and have even made significant inroads into the financial sector.

Another interesting observation that was apparent form the study revealed that most traditional manufacturing firms have very well organized web-portals, with significant support for language and country-based customization. Some of them even have individual portals for departments within their firms or individual products. However, the emerging firms have a small number of web-pages, often written in simple HTML, with minimal use of scripts and forms for collecting customer feedback or orders online. Again, there are some exceptions to this observation. For instance, Georg Fischer, which is a well diversified firm and which acquired Agie and Charmilles to form GF Agie Charmilles, has a good presence on the web, with individual portals for separate products. Likewise, Makino has a pretty well designed portal. The bottomline message that comes out of these observations is that these firms are on the growth phase and will soon be evolving into the multi-dimensional conglomerates that we can see in the form of Daimler AG, Renault, Lockheed Martin, GM etc.

Again, it is interesting to note that the revenues of the emerging firms are way below the traditional firms, with most of them still trading in millions, while the traditional firms are raking in the billions. As expected, it is only the traditional firms that have made it to the Fortune 500 list. Only exception to this is the case of GF Agie Charmilles, which is today a world leader in precision machine tools, such as wire-EDM, CNC machines etc.

and has succeeded in generating $1.07 billions in revenues, with $69.16 millions in profits. Although Fanuc has also generated revenues in billions, their revenues are a combined result of precision machine tools and industrial robotics, which may often go into serving the needs of traditional manufacturing firms. It is also important to understand in this context that the profit margins as a fraction of the revenue generated is higher on the average for micro-manufacturing and nano-technology firms. This is primarily because the products produced by these firms are often customized to meet the needs of a specific customer, whereas a traditional firm offers very little customization. An attempt has been made to summarize the understanding gained from this study in Table 3.

Table 3. Comparison of traditional firms with emerging micro- and nano- technology firms

Index of comparison	Traditional firms	Micro- and nano- technology firms
Inventory	High	Low, often use JIT
Production capacity	High	Low
Profit margins	High, but shrinking	Low, but increasing
Demand for innovation	High	Low (large number of patents from academia)
Supply Chain Management	High	Low
Competition	High	Low (mostly patented products)
Existing IT Infrastructure	Excellent	Poor
Need for expansion	Medium/Low	High
Workforce age	Aging, experienced	Youth, late 20s-mid 30s
Product customization	Low	High
Ease of incorporation of digital manufacturing	Difficult	Easy-moderate
Business diversification	High	Low
Volume of sales	High	Low
Profits per unit sales	Low	High

4. LEVERAGING IT EXPERTISE TO CREATE VALUE

It is quite apparent from Table 3 that micro-manufacturing and nano-technology firms, which are on the rise, are or soon will be facing escalating infrastructure needs coupled with the need to ensure efficient networking between individuals within the firms and customers, clients and professionals in the industry and academia on a

scale that would be comparable with the traditional firms, which already have the requisite infrastructure. This will, in turn, call for a comprehensive IT strategy to carry out the networking, as well as deliver services within the firms, be it in the form of an enterprise resource planning package, or an innovative digital manufacturing strategy, including and not limited to virtual manufacturing solutions, which are increasingly becoming popular with customers preferring to telecommute and issue orders online. Once this IT infrastructure is in place, it will then be necessary to maintain and upgrade the services on a continual basis.

Having said this, it is important to realize here that the IT needs of these emerging firms are bound to differ from those of the traditional firms in several respects which can be well understood from the differences that emerge in Table 3. A look at some of the key areas in which EDS has provided solutions for manufacturing firms emerges from a EDS viewpoint paper by Ram Prabhakar [26]. In this, he highlights the major solution areas for providing services as: i) IT alignment and governance, ii) Knowledge management and collaboration, iii) Industry Apps and standardization, iv) Business process improvement, v) Business insight and analysis, vi) work force mobility, vii) workplace management, and viii) Infrastructure network and security. To this measure, EDS has gone ahead and delivered solutions in each of these areas by developing a multivendor governance framework called Enterprise Service Management, bundled services that include infrastructure and applications, legacy modernization, ERP, PLM, MOM and CRM solutions, data warehousing analytics, wireless infrastructure and mobility solution and GSN network services including security.

Although the basic framework for providing solutions to the emerging firms shall remain more or less the same, the internal characteristics of these solutions will have to be quite different. This primarily arises from the fact that substantial scalability issues arise in the case of the emerging firms. For instance, the work-force of these firms, which may currently range from 100-2000 is likely to scale up in geometric proportions in the coming 5-10 years. The solutions provided to these firms, thus have to take into account the current resources and how they are likely to scale up as newer technologies appear in the market and change the internal functioning of these firms. Likewise, financial management issues are likely to be a cornerstone for the success of these firms and the solutions provided to them, be it enterprise applications that handle the payrolls or project management frameworks, would have to take into account the scale of operations currently and in the future, with optimal utilization of resources. Again, scope has to be provided for smooth handling of patents, as they come and expire, as very often these are developed in collaboration with the academia, with funding that may very often be provided by the government, as opposed to corporate research in traditional firms, which is very often internal. Again, telecommuting, which is mostly ruled out in the heavy manufacturing sector, becomes a reality in the case of these emerging firms, with the coming of age of desktop micro-factories [27], where manufacturing can be done literally anytime, anywhere, and you carry your entire machining setup including controllers home. Hence, solutions provided to these firms will have to consider the possibility of extending the IT infrastructure to be provided at individual one-off sites such as homes of employees, guest houses and even possibly to the personal/company vehicles where the company personnel can remotely monitor and control a manufacturing process and even manufacture products on the go. This will further necessitate the use of wireless and bluetooth networking technologies which will keep the employees connected to the manufacturing processes and the firm's needs round the clock. Such an agile manufacturing architecture was proposed earlier by Hollis et al. [28] and the emerging micro-manufacturing and nano-technology firms provide the right platform for EDS to step in and make this a reality by the incorporation of the needs discussed above in the solutions provided. A snapshot of some of these issues have been captured in a flow diagram shown below in Fig. 1.

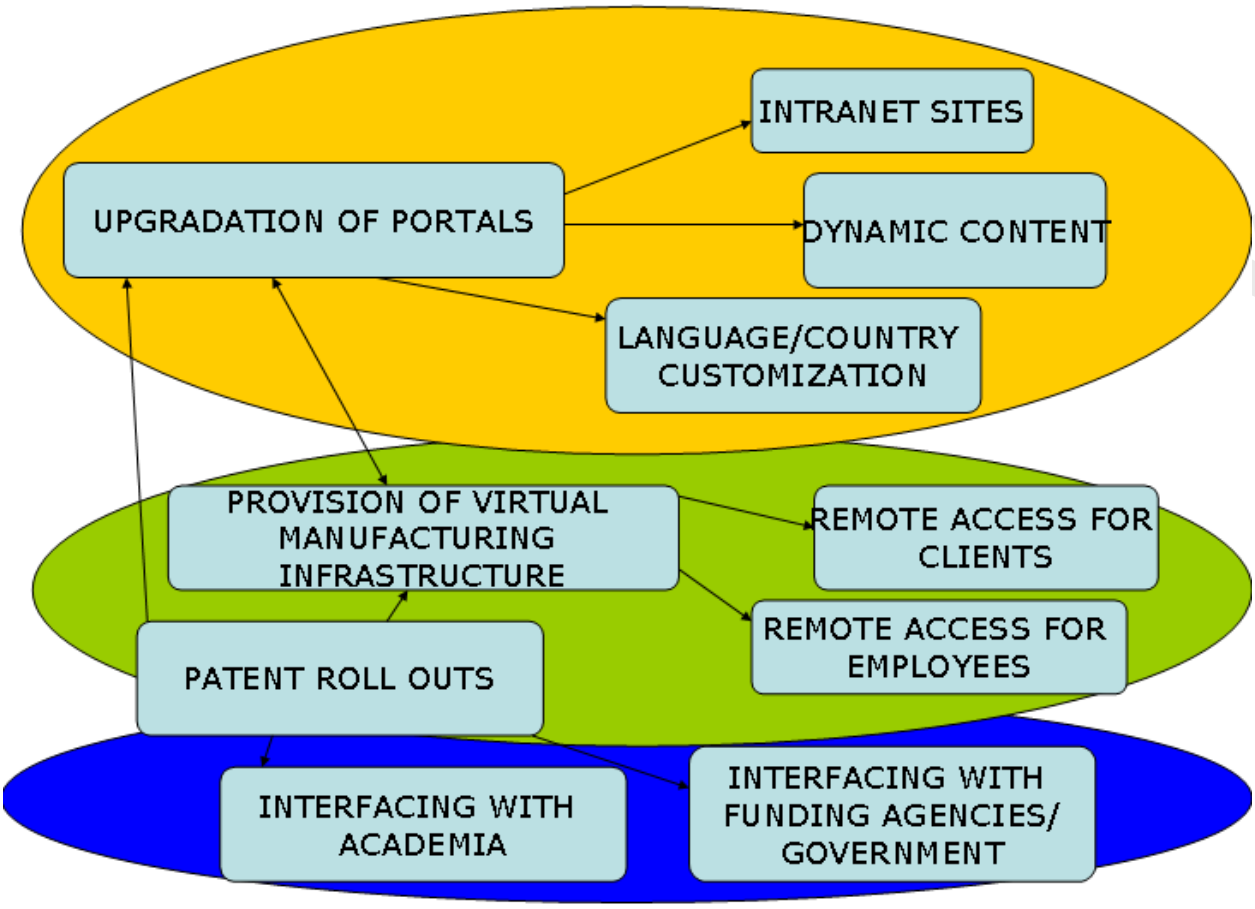

Fig. 1 Using IT expertise to develop solutions for micro- and nano-technology firms

5. CONCLUSIONS

Although traditional heavy manufacturing firms continue to lead the market, micro-manufacturing and nano-technology firms are making giant strides in the global market. As these emerging firms come out in the open and begin to diversify their portfolios, information management, transfer and processing comes forward as a major issue, which requires expertise in leveraging IT expertise to develop comprehensive and dynamic solutions. These firms also bring with them the exciting prospects of producing products anywhere and anytime, without any restrictions, provided they have access to the necessary remote tools. It is here that a global firm like EDS can come forward to develop solutions that help these firms grow steadily, while creating newer niche markets for itself, where it can rapidly deliver newer and innovative products that take micro-manufacturing and nano-technology firms into the next decade hand-in-hand with the traditional manufacturing firms.

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