

## **New Product Innovation Award Cognitive Computing Processors for Pattern Recognition North America, 2012**

### **Frost & Sullivan's Global Research Platform**

Frost & Sullivan is in its 50th year in business with a global research organization of 1,800 analysts and consultants who monitor more than 300 industries and 250,000 companies. The company's research philosophy originates with the CEO's 360-Degree Perspective™, which serves as the foundation of its TEAM Research™ methodology. This unique approach enables us to determine how best-in-class companies worldwide manage growth, innovation and leadership. Based on the findings of this Best Practices research, Frost & Sullivan is proud to present the 2012 North American New Product Innovation Award in the Cognitive Computing Processors for Pattern Recognition market to CogniMem Technologies Inc..

### **Significance of the New Product Innovation Award**

#### **Key Industry Challenges Addressed by CogniMem Technologies' Neural Network System-On-Chip CM1K**

Hardware that can perform parallel processing is becoming a ubiquitous component in computer processing technology nowadays. With the advent of multicore computing, Frost & Sullivan envisions a constant rate of growth with respect to the theoretically available compute capability. Alongside this growth, solutions to overcome the challenge of power requirements for such compute-intensive scenarios are also being uncovered.

In a real-time high-performance computing (HPC) application, oftentimes matrix vector multiplications are executed in parallel. In a multicore system, multiple computing engines work independently on different tasks and can complete intensive tasks concurrently and efficiently.

Frost & Sullivan points out that one challenge with multicore processors is in the area of software development. Parallelism in the source-code of an application through multi-threading is essential for faster performance benefits. Also, parallel architectures are implemented through multiple methods -- Field Programmable Gate Arrays (FPGAs), tiled many-core architectures, and manifold coprocessor concepts -- with no unified approaches or standards in place currently. Moreover, programming models involve vendor specific approaches and diverging concepts.

Today's fastest and most powerful computers are based on the von Neumann architecture -- where the processing unit includes an arithmetic logic unit and processor registers, a control unit with an instruction register and program counter, a memory to store both data and instructions. The connection between the memory and the processor can get overloaded, limiting the speed of the computer to the pace at which it can transfer data between the

two. Processors idle while waiting to get data from the memory, and adding more cores to the equation further reduces the speed and uses up resources. In addition, specific tasks require diverse and targeted programs in order to function as intended.

Frost & Sullivan feels that CogniMem Technologies' neural network system-on-chip CM1K resolves the memory bottleneck, in a superior fashion when compared to other market participants, by obviating the need for an instruction set in its processor architecture. By emulating a neuron's synaptic response in silicon, the company has enabled "true" parallelism and has opened the doors for high performance computing - at extremely low power and cost.

### Key Benchmarking Criteria for New Product Innovation Award

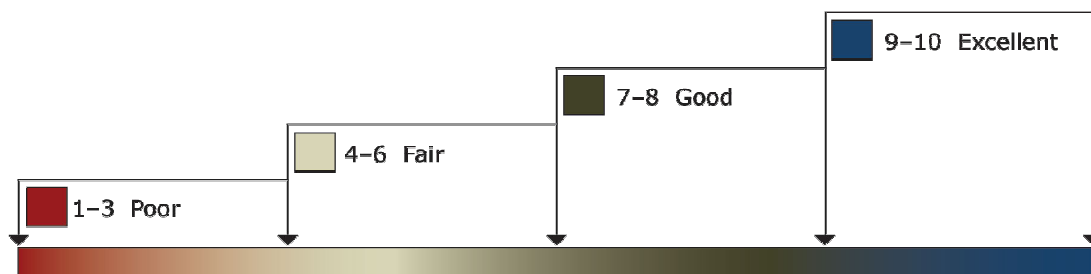
For the New Product Innovation Award, the following criteria were used to benchmark CogniMem Technologies' performance against key competitors:

- **Innovative Element of the Product**
- **Leverage of Leading-Edge Technologies in Product**
- **Value Added Features/Benefits**
- **Increased Customer ROI**
- **Customer Acquisition/Penetration Potential**

### Decision Support Matrix and Measurement Criteria

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Matrix (DSM). The DSM is an analytical tool that compares companies' performance relative to each other with an integration of quantitative and qualitative metrics. The DSM features criteria unique to each Award category and ranks importance by assigning weights to each criterion. The relative weighting reflects current market conditions and illustrates the associated importance of each criterion according to Frost & Sullivan. Fundamentally, each DSM is distinct for each market and Award category. The DSM allows our research and consulting teams to objectively analyze each company's performance on each criterion relative to its top competitors and assign performance ratings on that basis. The DSM follows a 10-point scale that allows for nuances in performance evaluation; ratings guidelines are shown in Chart 2.

**Chart 2: Performance-Based Ratings for Decision Support Matrix**



This exercise encompasses all criteria, leading to a weighted average ranking of each company. Researchers can then easily identify the company with the highest ranking. As a final step, the research team confirms the veracity of the model by ensuring that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.

**Chart 3: Frost & Sullivan’s 10-Step Process for Identifying Award Recipients**



### **Best Practice Award Analysis for CogniMem Technologies Inc.**

The Decision Support Matrix, shown in Chart 4, illustrates the relative importance of each criterion for the New Product Innovation Award and the ratings for each company under evaluation. To remain unbiased while also protecting the interests of the other organizations reviewed, we have chosen to refer to the other key players as Competitor 1 and Competitor 2.

**Chart 4: Decision Support Matrix for New Product Innovation Award**

<i>Measurement of 1-10 (1 = lowest; 10 = highest)</i>	<b>Award Criteria</b>					
	Innovative Element of the Product	Leverage of Leading-Edge Technologies in Product	Value Added Features/Benefits	Increased Customer ROI	Customer Acquisition/Penetration Potential	<b>Weighted Rating</b>
<b>Relative Weight (%)</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>20%</b>	<b>100%</b>
<b>CogniMem Technologies Inc.</b>	<b>9.5</b>	<b>9.5</b>	<b>9.0</b>	<b>8.0</b>	<b>9.0</b>	<b>9.0</b>
Competitor 1	8.0	8.5	7.5	7.0	7.5	7.7
Competitor 2	7.5	8.0	8.0	7.0	7.0	7.5

### **Criterion 1: Innovative Element of the Product**

CogniMem Technologies has enabled “true” parallel processing in a multicore environment through its CM1K integrated circuit (IC) that emulates a neuron’s synaptic response. In essence, none of the issues that bog down the performance of today’s multicore processors, such as cache coherency, clock synchronization, or scalability seem to affect CogniMem’s pattern recognition chip. The core of the CM1K chip packs 1024 hardware-based neurons that implement a fully parallel, low power, non-linear classifier/recognizer. Without the need for any pre-programming, the classifier nicely creates models based on learning and compares an incoming pattern to the learned model. This solution truly is an adaptive, re-trainable and general purpose learning device.

Based on the K-Nearest Neighbor (KKN) and Restricted Coulomb Energy or Radial Basis Function (RCE/RBF) algorithms, the CM1K can find the closest match for a 256 byte vector to 1024 stored (via real time or off-line learning) vectors in 10  $\mu$ sec.

The impact of these aspects boils down to fetching information from the memory to the processor. While the von Neumann processor idles while waiting for data from memory, CogniMem’s synaptic processor entails neurons that function independently to enable true parallelism. Running at half a watt, the chip can prove useful for machine vision, digital signal processing, target tracking, event detection, and motion control, among other applications.

Competitor 1 specializes in programmable image cognition processors. With 96 computational units operating in parallel with an ARM processor, the altered core extracts

the feature information from image data, while an ARM processor further analyzes these extracted features. Integrating a single instruction multiple data (SIMD) core with a reduced instruction set computing (RISC) processor core maximizes the parallelism achievable through SIMD architecture. Nevertheless, the CM1K architecture, by simulating a neuron, can store memories, evaluate distance vectors, perform associative recognition, learn and classify objects based on training examples.

Competitor 2's technology uses a similar integration of FPGA and DSP for post processing. While FPGAs offer a higher degree of parallelism over DSPs, they are generally more difficult to program and often require a RISC for post-processing data. Also, FPGAs have high power consumption, large system footprint, and are a more costly solution overall.

## **Criterion 2: Leverage of Leading-Edge Technologies in Product**

Leading edge technologies often enable new product development and help the technology foray into new application markets. New conceptual breakthroughs often lead to cutting edge product designs that influence the market in a big way, resulting in widespread adoption of the technology. Identification of these markets which offer the newest avenues for growth is the key factor.

The CM1K chip is based on the zero instruction set computing (ZISC) technology which enables pattern matching without the need for microinstructions, unlike the RISC machines or DSPs of today. Each neuron functions independently as a processing element, as well as an integrated memory with learning capability. The ZISC processor is thus capable of performing an evaluation in less than four microseconds, rendering it of immense value in real time applications. This kind of massive parallel architecture, combined with neural network technology, offers a rapid and cost-effective processing domain for pattern recognition.

The CogniMem CM1K Chip features 1024 neurons working in parallel to implement two renowned non-linear classifiers. The Radial Basis Function (RBF) enables learning in neural networks. Unnecessary computation time is curbed by the algorithm, which simplifies computations significantly through robust generalizations. The k-nearest neighbor algorithm (k-NN) classifies objects based on the closest examples trained in the feature space. As such, the daisy-chained neurons have two distinct behaviors based on these two field-proven algorithms. Patents have been developed jointly by the company's founder Guy Paillet and IBM and are sold under the terms of a license with IBM.

Other competitors' technologies implement massive parallel processing with shared-memory, highly-networked core architecture. While it may be a cost-optimized method to solve some pattern matching problems, the memory bottleneck continues to exist, which means that the architecture cannot be scaled well enough.

**Criterion 3: Value Added Features/Benefits**

The pattern recognition processor based on neurons is representative of a new generation of computer science, driven by the demand for huge clusters of computers in giant data centers that are needed for high performance computing. Frost & Sullivan monitors the various ways that this solution is leading to significant advances in areas as diverse as machine vision and perception, speech recognition and language translation.

Besides increased accuracy and improved quality control, the company's neural network processor chips offer reduced costs, as the trainable system does not demand maintenance costs. CogniMem introduced the Cogniblox in November 2011 at a Supercomputing conference. The vertically stackable evaluation board includes four CM1K chips with memory and a variety of input to expand functionality horizontally. The MRAM that runs on the board, supplied by Everspin Technologies, offers the speed of a static RAM (SRAM), as well as non-volatility, which ensures that the learning is saved even in the event of a power interruption. The board can process images 4 times faster, with data being distributed to the multiple CM1K chips. Applications span machine vision and speech recognition to data mining.

**Criterion 4: Increased Customer ROI**

Today's fast-paced manufacturing environments necessitate smarter and more efficient results. A self-learning system empowers manufacturers, allowing them to address key concerns and issues without affecting cost, quality, or production rates. As such, the CogniMem system increases performance/watt by  $10^3$  for the best industrial application solution and making pattern recognition possible for varied applications.

In order to support its customers and enhance the value offered through CogniMem's technology, the CM1K is supported by several evaluation/development systems targeting simple robotics to data mining. One includes a vision sensor module with a library for image learning and recognition. The software development kits (SDK) enable programming in C, C# and Java under Windows and Linux.

**Criterion 5: Customer Acquisition/Penetration Potential**

Cognitive computing is still in its nascence. There are not many companies with a direct focus on developing neural network-based pattern recognition chips. As with any new technology, the challenge of marketing the technology, as well as educating customers, is inherent. In such a scenario, Frost & Sullivan believes that customer profiling can prove to be most useful. Analyzing customer demographics can help in identifying customer segments that would most benefit from the technology and products.

Being the only developer of neural network processor technology to offer a solution for pattern recognition and machine vision, CogniMem Technologies has a unique value

proposition, especially for the critical application segments it targets. At the same time, the capabilities of CogniMem's neural network processor lends itself to newer applications – for instance, the scalable pattern recognition, used in combination with Microsoft Kinect, can be used to enable gesture controls for Google Earth applications. Expanding on this, company executives believe that the technology could enhance game-playing experiences and eventually eliminate the need for remote controls for an immersive television experience.

## Conclusion

The most powerful computers and processors today are based on the von Neumann architecture. In such architecture, it is often found that the processor is idling while waiting for data from memory. Apart from wasting system resources, memory bottlenecks are frequent in a multicore environment, which considerably limits processor speed.

CogniMem's CM1K chip is based on a ZISC processor that consists of 1024 neurons to implement parallel neural network architecture. Based on adaptive learning, the non-linear classifier algorithm compares a pattern to the learned model. With each of the neurons operating independent of each other, the ZISC processor can perform evaluations in just a few microseconds and proves to be an innovative solution for intensive pattern recognition challenges. Based on the aforementioned criteria as benchmarked through Frost & Sullivan independent analysis, CogniMem is the recipient of the 2012 New Product Innovation Award.

## The CEO 360-Degree Perspective™ - Visionary Platform for Growth Strategies

The CEO 360-Degree Perspective™ model provides a clear illustration of the complex business universe in which CEOs and their management teams live today. It represents the foundation of Frost & Sullivan's global research organization and provides the basis on which companies can gain a visionary and strategic understanding of the market. The CEO 360-Degree Perspective™ is also a "must-have" requirement for the identification and analysis of best-practice performance by industry leaders.

The CEO 360-Degree Perspective™ model enables our clients to gain a comprehensive, action-oriented understanding of market evolution and its implications for their companies' growth strategies. As illustrated in Chart 5 below, the following six-step process outlines

how our researchers and consultants embed the CEO 360-Degree Perspective™ into their analyses and recommendations.

**Chart 5: The CEO's 360-Degree Perspective™ Model**



### Critical Importance of TEAM Research

Frost & Sullivan’s TEAM Research methodology represents the analytical rigor of our research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all seven of Frost & Sullivan's research methodologies. Our experience has shown over the years that companies too often make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Frost & Sullivan contends that successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. In that vein, the letters T, E, A and M reflect our core technical, economic, applied (financial and best practices) and market analyses. The integration of these research disciplines into the TEAM Research methodology provides an



evaluation platform for benchmarking industry players and for creating high-potential growth strategies for our clients.

**Chart 6: Benchmarking Performance with TEAM Research**



### About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best-in-class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best-practice models to drive the generation, evaluation and implementation of powerful growth strategies. Frost & Sullivan leverages 50 years of experience in partnering with Global 1000 companies, emerging businesses and the investment community from more than 40 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.