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FROST & SULLIVAN BEST PRACTICES AWARD

SYSTEM-ON-CHIP ARTIFICIAL INTELLIGENCE SENSOR FOR FAST EDGE PROCESSING - NORTH AMERICA

Technology Innovation 2019

AISTORM

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2019 BEST PRACTICES AWARD

Contents

Background and Company Performance

Industry Challenges

Edge computing is increasingly finding adoption and proliferation because it offers a local data processing scheme, wherein data is processed by a device, local computer, or server near the edge of the network where the data is generated, rather than in a centralized data processing center. Edge computing provides increased and faster network performance. Artificial intelligence (AI) is a key driver of edge computing that enables improved decision making at the edge and makes edge devices smarter.

AI accelerators, or AI chips, are new-age chipsets specifically designed to carry out parallel processing enabled by embedded machine learning algorithms. The four major types of AI accelerators include graphics processing units (GPUs), central processing units (CPUs), field programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), and neural processing units (NPUs). Emerging industry trends, such as new handset features, Industry 4.0, smart cities, and autonomous vehicles, have increased the demand for AI chipsets that can perform high-speed parallel computation. In addition, the rapid proliferation of Internet-of-Things (IoT) demands the real-time processing of data when delivering the decisive output. The proliferation of IoT trends is a major trigger for embedding intelligence into edge devices, such as smartphones and wearables. Despite advancements in AI and IoT, certain challenges remain in facilitating AI-based edge computing using incumbent processor architectures, such as GPUs and NPUs.

In edge computing applications, sensors generate large amounts of data in an analog format; however, most AI systems require information in a digital format to process the data. The analog data that needs to be processed to a digital format requires deep submicron GPU/NPU-based solutions for accelerating AI in edge devices. GPUs/NPUs are not well suited for portable devices because they consume more power and cause digitization delays (latency). Moreover, these solutions cannot intelligently select the valid data from the sensor, instead having to collect and process large volumes of data, which in turn consumes a significant amount of time and impedes efficiency.

The above-mentioned challenges underscore the need for a sensor for edge computing and AI that enables faster, real-time processing and intelligent pruning of the most relevant data from the sensor data stream; consumes low power; and is cost effective.

Technology Attributes and Future Business Value

Industry Impact

California-based AIStorm has developed a novel AI-in-Sensor (AIS) technology that enables real-time processing of analog sensor data at the edge, without digitization. The AIS technology uses a new patented technique called charge domain processing that controls the electron movement between the storage elements in the chip and uses switched charge circuits for mathematical control over the charge transfer. The company has developed a novel solution that has the opportunity to disrupt the currently used GPU/NPU-based edge processing methods by integrating the processing chip with the sensor to process and transport the sensor data of edge devices quickly and efficiently.

Furthermore, the solution allows the vital sensor data to be sifted intelligently and in real time to optimize edge computing applications that require massive amounts of sensor data. Finally, AIStorm's solutions enable "always on" imaging and audio event driven capability without polling, with an intelligent AI-based trigger mechanism, thus eliminating false triggers and using almost no power while waiting for an event.

GPUs that are currently used for AI acceleration and edge computing require more complex circuit design architectures for processing the incoming analog sensor data, which creates latency issues and consumes more power for data processing. AIStorm's AIS technology solves this problem by eliminating the need to transmit analog sensor data to a different processor. The real-time processing of analog sensor data takes place inside the sensor itself for decision making and machine learning, thereby reducing the cost, response latency, and security hazards of transmitting large amounts of raw sensor data.

AIStorm's AIS technology impacts several industries, such as consumer electronics, automotive, healthcare, industrial, and food service, in terms of developing novel smartphones, wearables, AI assistants, biometric devices, and imager applications. The company strategically collaborates with other industry participants, such as original equipment manufacturers (OEMs) and chip manufacturers, to develop solutions for specific application needs. For example, AIStorm collaborated with TowerJazz, a global image sensor foundry that is incorporating AIStorm's AIS technology into its complementary metal-oxide-semiconductor (CMOS) image sensors, which are expected to be used in multiple applications from advanced driver-assistance system (ADAS) to handsets, wearables, infrastructure access, smart cities and IoT.

Product Impact

Based on its AIS technology, AIStorm has developed an AIS system-on-a-chip (SoC) that enables rapid AI processing at the network edge. The processors, AIStorm's IoT Vision and Waveform chips, are designed to be integrated within sensors, which can be embedded in smartphones, self-driving cars, and IoT connected devices, to process the data within the sensors.

AIStorm's patented chips are designed to be single chips integrating imagers (CIS or Lidar), voice (MEMs microphones), or waveform (vibration or motion) sensors as well as flow, network, memory, power management, and communications tasks. The charge domain AI processing eliminates the expensive digitization process (communicating digitally only the final results) & the single chip solution simplifies adoption. This novel technology will open up new opportunities in smart, high-speed processing at the edge and event-driven operations for customers. Compared with GPU-based systems, AIStorm's 7 × 7 millimeter (mm) chip can operate at 2.5 Tera Operations Per Second (TOPS) and several 10's of TOPS per watt depending upon application, which is five to ten times lower than the standard GPU-based system's power consumption.

AIStorm has an SDK compatible with Google's TensorFlow Lite architecture, is fully programmable, and is focused on leading mobile architectures, several of which have been optimized by AIStorm as starter applications for customers. In certain cases, efficiency

can reach into the 100's of TOPs/W allowing AIStorm's chipsets to empower biometric authentication in devices, such as augmented reality glasses, smart watches, agricultural/difficult to access cameras, with multi-year battery life. The company is working on 180nm silicon wafer processes for and plans to sample chips by the end of 2019 and then commercialize them in 2020.

Furthermore, AIStorm partners with OEMs and suppliers in target industries to commercialize its innovative, patented AIS technology. AIStorm differentiates itself in the AI-based edge computing industry by developing low-cost, off-the-shelf, and integrated sensors and processors that are easy to manufacture and do not incur excessive integration costs for users.

Application Diversity

AIStorm's AIS technology was initially targeted for biometric authentication; however, because of its technological attractiveness and competence, the product's application landscape has been diversified. For example, the company's disruptive AIS technology is valuable for a wide range of applications, such as security/access control, automotive, industrial automation, and healthcare. The fastest-growing application is security/access & HID because the AIS technology can be integrated into smartphones, wearables, cameras, and IoT devices for imaging and biometric authentication, such as facial/voice recognition, occupancy sensing, fingerprint sensing, gesture control, heart rate monitoring, and heart based authentication.

Currently, digital processing techniques for edge computing require expensive and advanced NPUs/GPUs for the continuous digitization of input data, which causes inevitable digitization delay and consumes significant power. Even though GPU/NPU-based solutions are currently leveraged to accelerate AI in edge devices, higher sensitivity is still needed in critical applications for more efficient and effective digital processing techniques. For example, solutions utilizing deep submicron GPU techniques for accelerating AI at the edge have challenges in terms of meeting real-time processing, power, and cost, all of which are beyond the capabilities of most conventional processing techniques.

As AIStorm's technology is VLSI scalable, it is poised to impact several other sectors as well in the near future, such as unmanned aerial vehicles, robotics, servers, and ADAS applications. For example, AIStorm has been able to create imagers capable of operating at several 10's of thousands of frames per second and due to AIS technology can handle the AI processing of the enormous amount of resulting data in real time.

Frost & Sullivan has identified AIStorm's versatile approach in determining diverse promising application fields for its technology as a viable and exemplary strategy for gaining a competitive market advantage.

Customer Acquisition and Technology Licensing

Founded in 2018, based upon technology in development since 2013, AIStorm has demonstrated a long-term commitment to both its AIS technology and optimized mobile algorithm technology by filing global patents on key ideas, such as process in memory,

charge domain based neural networks, event driven processing, high speed integrated imagers and many others that drive intellectual property (IP) and revenue streams. AIStorm typically follows a standard semiconductor business model by developing integrated solutions including algorithms/AI models as well as optimized integrated AI processors & sensors to clients through direct sales, distributors, and company representatives. AIStorm's business model is similar to the business model followed by semiconductor manufacturing companies, such as Maxim Integrated Products, Microchip Technology Inc, and Silicon Labs.

To date, AIStorm has secured $13.2 million in Series A funding from Egis Technology Inc, a key biometrics supplier of ADAS, gaming, and smartphones; TowerJazz, a foundry that focuses on image sensors for the commercial, industrial, augmented reality, and medical markets; Meyer Corporation, a key participant in food preparation equipment; and Linear Dimensions Semiconductor Inc, a key provider of biometric authentication and digital health solutions. The strategic funding from these investors is expected to accelerate AIStorm's business and go-to-market efforts in developing novel machine-learning-to-the-edge solutions using cost-effective analog technologies.

AIStorm is partnering with multiple ecosystem participants that plan to integrate the company's technology into their future products. For example, AIStorm has established partnerships with its investors, such as Egis Technology Inc and TowerJazz, to form a co-development and mass-manufacturing association for developing high-performance AI-in-sensor processors. These partnership agreements will provide AIStorm with high-level entry into the imaging and biometric authentication and identification markets, while allowing OEMs to design their products in a customized and cost-effective manner.

AIStorm is based in Silicon Valley with offices in Austria, Hungary, and Ohio. To address the growing opportunity of its AIS solutions and tap the market, AIStorm is expanding its on-ground business development teams & is presently undertaking a Series B fundraising. The company is further increasing its customer base by aggressively marketing its products and reaching out to targeted segments, such as smartphones, infrastructure, IoT, ADAS, and wearables. For example, AIStorm launched its first analog data AI solutions at the 2019 Mobile World Congress Event in Barcelona. By segmenting its customer base, AIStorm can acquire new customers through active customer engagement activities and by participating in various technical events and workshops, to showcase its products worldwide.

Frost & Sullivan recognizes that the combined force of AIStorm's technology partnerships and its wide application applicability, ranging from facial recognition to access control, provide AIStorm with the opportunity to disrupt the market and capture an impressive market share.

Human Capital

AIStorm's highly efficient resources and strong IP portfolio are key factors that have contributed to the development of its industry-leading SoC AIS platform. In addition, AIStorm fosters a diverse work culture that promotes technological innovation and

provides employees with the flexibility to implement their workflow responsibilities, thus ensuring a fast turnaround time on proposed ideas and offering customized solutions through continuous feedback and by strongly engaging with clients. Consequently, the company maintains a high employee retention rate, with several experienced engineering, manufacturing, and business leaders in the semiconductor industry that have contributed to significant revenue growth at top semiconductor companies. In addition, the skills of its technologists have enabled the company to file key patents related to its low-power analog integrated circuit architecture and real-time edge processing methods.

AIStorm has gained a strong competitive advantage in the industry by developing a highly innovative AIS platform through its IP portfolio, team of engineers, and experienced leadership and has established a workplace culture of innovation and creativity.

Conclusion

AIStorm's AIS solution, powered by its charge domain and switched charge circuit processing technology, has the opportunity to overcome the shortcomings of existing GPUs and NPUs for high-performance, AI-based edge computing applications and is positioned to become a significant standard for edge computing and AI systems.

The company's AIS solution provides real-time sensing and AI edge processing in the native analog format with low-power utilization for optimized processor performance in the same module, without requiring an additional circuitry design for the analog-to-digital conversion. AIStorm's technology can be integrated into existing facilities to enhance and streamline applications in a wide range of industries, including consumer, automotive, security, medical imaging, and industrial automation.

With its strong overall performance and ability to enhance AI-based edge computing by more effectively pruning and leveraging the most vital sensor data from the massive data stream, AIStorm has earned Frost & Sullivan's 2019 Technology Innovation Award for its SoC AI sensor in the North American fast edge processing industry.

Significance of Technology Innovation

Ultimately, growth in any organization depends on finding new ways to excite the market and maintaining a long-term commitment to innovation. At its core, technology innovation, or any other type of innovation, can only be sustained with leadership in 3 key areas: understanding demand, nurturing the brand, and differentiating from the competition.

Understanding Technology Innovation

Technology innovation begins with a spark of creativity that is systematically pursued, developed, and commercialized. That spark can result from a successful partnership, a productive in-house innovation group, or a bright-minded individual. Regardless of the source, the success of any new technology is ultimately determined by its innovativeness and its impact on the business as a whole.

Key Benchmarking Criteria

For the Technology Innovation Award, Frost & Sullivan analysts independently evaluated 2 key factors—Technology Attributes and Future Business Value—according to the criteria identified below.

Technology Attributes

Criterion 1: Industry Impact
Criterion 2: Product Impact
Criterion 3: Scalability
Criterion 4: Visionary Innovation
Criterion 5: Application Diversity

Future Business Value

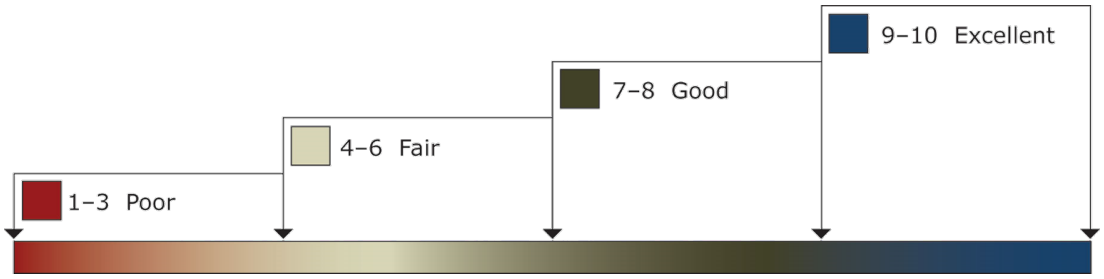
Criterion 1: Financial Performance
Criterion 2: Customer Acquisition
Criterion 3: Technology Licensing
Criterion 4: Brand Loyalty
Criterion 5: Human Capital

Best Practices Award Analysis for AIStorm

Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows research and consulting teams to objectively analyze performance according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation. Ratings guidelines are illustrated below.

RATINGS GUIDELINES



The Decision Support Scorecard considers Technology Attributes and Future Business Value (i.e., the overarching categories for all 10 benchmarking criteria; the definitions for each criterion are provided beneath the scorecard). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms 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.

The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, Frost & Sullivan has chosen to refer to the other key participants as Competitor 1 and Competitor 2.

Measurement of 1–10 (1 = poor; 10 = excellent)			
Technology Innovation	Technology Attributes	Future Business Value	**Average Rating**
AIStorm	**9.5**	**9.5**	**9.50**
Competitor 1	9	9	9.00
Competitor 2	8.5	8	8.25

Technology Attributes

Criterion 1: Industry Impact

Requirement: Technology enables the pursuit of groundbreaking ideas, contributing to the betterment of the entire industry.

Criterion 2: Product Impact

Requirement: Specific technology helps enhance features and functionalities of the entire product line for the company.

Criterion 3: Scalability

Requirement: Technology is scalable, enabling new generations of products over time, with increasing levels of quality and functionality.

Criterion 4: Visionary Innovation

Requirement: Specific new technology represents true innovation based on a deep understanding of future needs and applications.

Criterion 5: Application Diversity

Requirement: New technology serves multiple products, multiple applications, and multiple user environments.

Future Business Value

Criterion 1: Financial Performance

Requirement: Potential is high for strong financial performance in terms of revenue, operating margins, and other relevant financial metrics.

Criterion 2: Customer Acquisition

Requirement: Specific technology enables acquisition of new customers, even as it enhances value to current customers.

Criterion 3: Technology Licensing

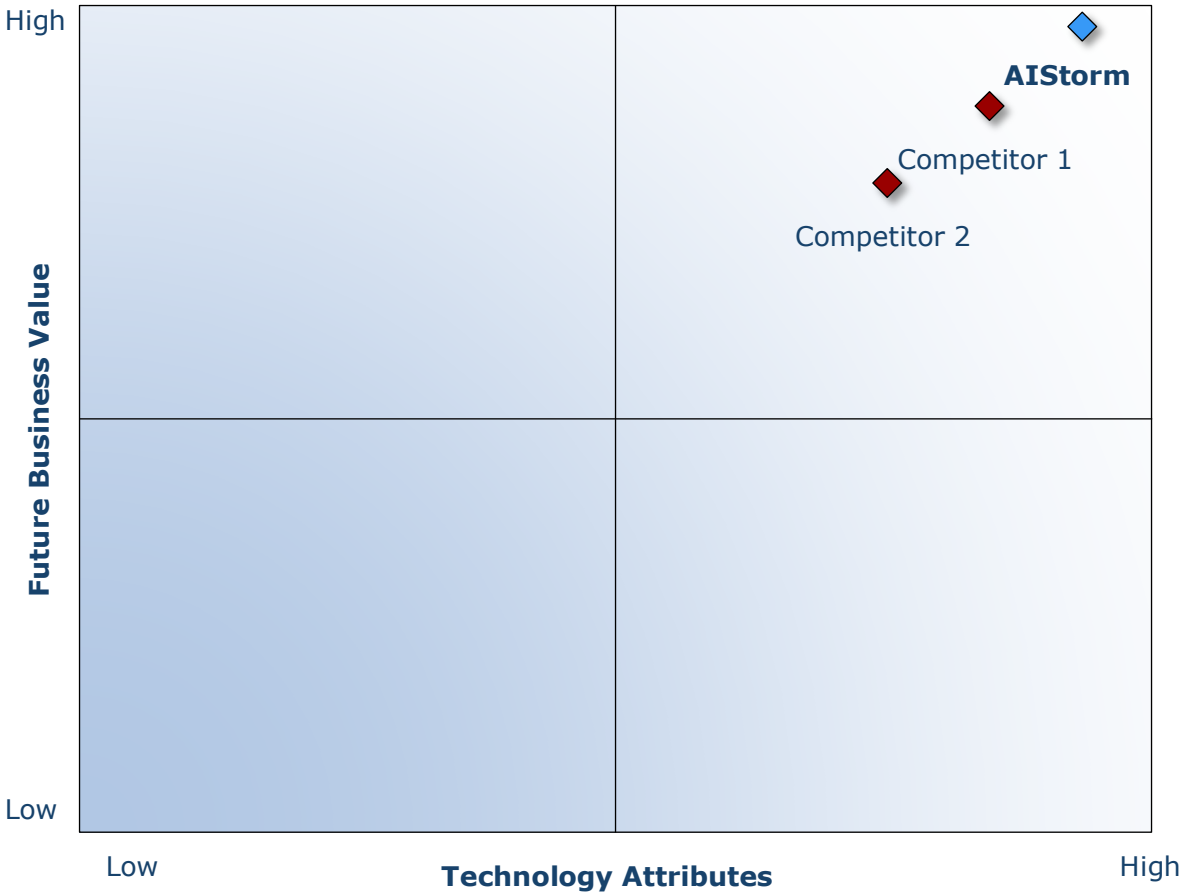
Requirement: New technology displays great potential to be licensed across many verticals and applications, thereby driving incremental revenue streams.

Criterion 4: Brand Loyalty
Requirement: New technology enhances the company's brand, creating and/or nurturing brand loyalty.

Criterion 5: Human Capital
Requirement: Customer impact is enhanced through the leverage of specific technology, translating into positive impact on employee morale and retention.

Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

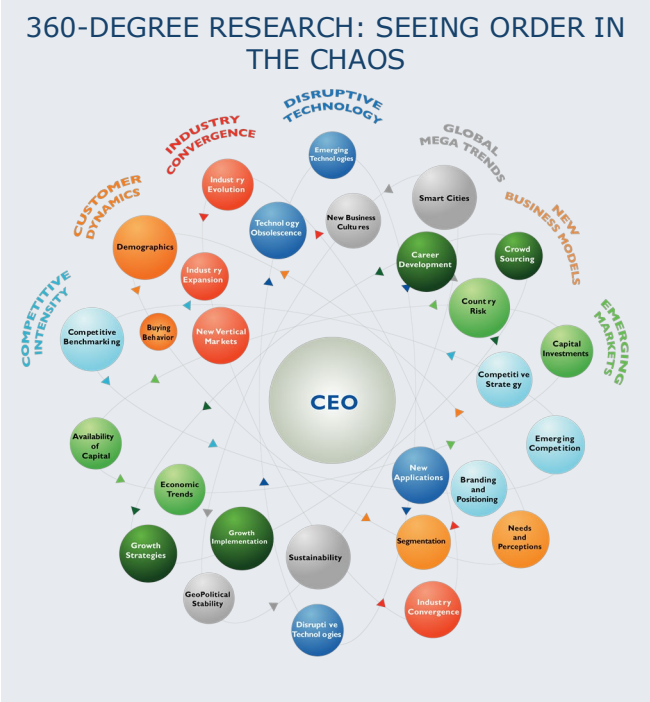
Frost & Sullivan analysts follow a 10-step process to evaluate award candidates and assess their fit with select best practices criteria. The reputation and integrity of the awards are based on close adherence to this process.

STEP		OBJECTIVE	KEY ACTIVITIES	OUTPUT
1	**Monitor, target, and screen**	Identify award recipient candidates from around the world	• Conduct in-depth industry research • Identify emerging industries • Scan multiple regions	Pipeline of candidates that potentially meet all best practices criteria
2	**Perform 360-degree research**	Perform comprehensive, 360-degree research on all candidates in the pipeline	• Interview thought leaders and industry practitioners • Assess candidates' fit with best practices criteria • Rank all candidates	Matrix positioning of all candidates' performance relative to one another
3	**Invite thought leadership in best practices**	Perform in-depth examination of all candidates	• Confirm best practices criteria • Examine eligibility of all candidates • Identify any information gaps	Detailed profiles of all ranked candidates
4	**Initiate research director review**	Conduct an unbiased evaluation of all candidate profiles	• Brainstorm ranking options • Invite multiple perspectives on candidates' performance • Update candidate profiles	Final prioritization of all eligible candidates and companion best practices positioning paper
5	**Assemble panel of industry experts**	Present findings to an expert panel of industry thought leaders	• Share findings • Strengthen cases for candidate eligibility • Prioritize candidates	Refined list of prioritized award candidates
6	**Conduct global industry review**	Build consensus on award candidates' eligibility	• Hold global team meeting to review all candidates • Pressure-test fit with criteria • Confirm inclusion of all eligible candidates	Final list of eligible award candidates, representing success stories worldwide
7	**Perform quality check**	Develop official award consideration materials	• Perform final performance benchmarking activities • Write nominations • Perform quality review	High-quality, accurate, and creative presentation of nominees' successes
8	**Reconnect with panel of industry experts**	Finalize the selection of the best practices award recipient	• Review analysis with panel • Build consensus • Select recipient	Decision on which company performs best against all best practices criteria
9	**Communicate recognition**	Inform award recipient of recognition	• Present award to the CEO • Inspire the organization for continued success • Celebrate the recipient's performance	Announcement of award and plan for how recipient can use the award to enhance the brand
10	**Take strategic action**	Upon licensing, company is able to share award news with stakeholders and customers	• Coordinate media outreach • Design a marketing plan • Assess award's role in strategic planning	Widespread awareness of recipient's award status among investors, media personnel, and employees

The Intersection between 360-Degree Research and Best Practices Awards

Research Methodology

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of the research process. It offers a 360-degree view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often companies make important growth decisions based on a narrow understanding of their environment, resulting in errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry participants and for identifying those performing at best-in-class levels.



About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, helps clients 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-practices models to drive the generation, evaluation, and implementation of powerful growth strategies. Frost & Sullivan leverages nearly 60 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on 6 continents. To join Frost & Sullivan's Growth Partnership, visit http://www.frost.com.