Phase I Small Business Innovation Research (SBIR) Program

Proposal Cover Sheet

Proposal Number: N011-0978 **Agency:** NAVY
Topic Number: N01-082
Proposal Title: Application of JINI Technology to Tactical System Integration
Firm Name: INTEG process group, inc.
Mail Address: [redacted]
[redacted]
Pittsburgh, PA [redacted]
Web Address: www.integpg.com

Proposed Cost: [redacted] Phase: I Duration: 6
Option Cost: 0 Option Duration: 0

BUSINESS CERTIFICATION:

Are you a small business as defined in paragraph 2.2? YES
Number of employees including all affiliates (average for preceding 12 months): [redacted]
Are you a socially or economically disadvantaged business as defined in paragraph 2.3? NO
Are you a woman-owned small business as described in paragraph 2.4? NO
Has this proposal been submitted to other US government agencies, or DoD components or other SBIR activity? NO
If yes, list the name(s) of the agency, DoD component or other SBIR office and Topic Number in the space below.
Is your company (either directly or as a subcontractor) performing work for a Navy activity outside of SBIR or STTR funded work? NO.
If so, please indicate the organization and the specific code in which this work is performed in the space below.

Project Manager/Principal Investigator
Name: [redacted]
Title: Systems Engineer
Phone: [redacted]
Fax: [redacted]
E-Mail: [redacted]

Corporate Official (Business)
Name: [redacted]
Title: Vice President
Phone: [redacted]
Fax: [redacted]
E-Mail: [redacted]

For any purpose other than to evaluate the proposal, the data referenced below shall not be disclosed outside the Government and shall not be duplicated, used or disclosed in whole or in part, provided that if a contract is awarded to this proposer as a result of or in connection with the submission of this data, the Government shall have the right to duplicate, use or disclose the data to the extent provided in the funding agreement. This restriction does not limit the Government's right to use information contained in the data if it is obtained from another source without restriction. The data subject to this restriction is contained on the pages of the proposal listed on the line below.

Proprietary Information:

[redacted] 1/8/01 [redacted] 1/8/01

Signature of Principal Investigator Date Signature of Corporate Business Official Date

Technical Abstract (Limit your abstract to 200 words with no classified or proprietary information/data.)

The objective of this proposal is to demonstrate the feasibility of using Jini technology to simplify the construction and implementation of inter-subsystem communication networks that contain a variety of operating platforms. The focal point of the research will be to develop a Jini compliant network architecture that is extensible to accommodate the sharing of services and resources in real-time. The Jini protocol describes a network software architecture where plug-n-play devices connect into a self-aware environment. The resultant system functions seamlessly as a single entity or "federation" that is dynamic and independent of the underlying platforms. At the end of Phase 1 we will determine the system requirements for a Jini enabled network infrastructure and demonstrate a rapid prototype developed with commercially available components.

Anticipated Benefits/Potential Commercial Applications of the Research or Development.

There is a tremendous need in the industrial automation and control marketplace for reliable communication networks and protocols that provide universal, spontaneous plug-and-play connectivity of diverse systems. Jini technology is an attractive solution to plug-n-play device communication as it is platform independent, scalable, and extensible. INTEG Process Group, Inc. is currently developing Java based factory automation and control solutions to meet the growing interest in TCP/IP connectivity for both new and legacy systems. Jini offers the opportunity to develop community based software extensions that can be used as non-proprietary standards allowing for seamless plug-n-play between multiple vendors providing solutions in specific marketplaces. At the end of Phase 1 the firm will have developed the requirements, specifications, and benchmarks for a device based network architecture that has the potential to provide lower-cost solutions to customers in the process control, factory automation, and transportation industries.

List a maximum of 8 Key Words that describe the Project.

Jini, Internet, Computers, Information Systems, Java, Networks, Real-Time

DOD SBIR Phase I Proposal

Topic Number: N01-082

Application of JINI Technology to Tactical System Integration

1. COVER SHEET (Formerly Appendix A - See Cover Sheet)

2. PROJECT SUMMARY (Formerly Appendix B – See Cover Sheet)

3. IDENTIFICATION & SIGNIFICANCE OF THE OPPORTUNITY

The objective of this proposal is to demonstrate the feasibility of using Jini™ technology to simplify the construction and implementation of inter-subsystem communication networks that contain a variety of operating platforms. The focal point of the research will be to develop a Jini compliant network architecture that is extensible to accommodate the sharing of services and resources in real-time. The Jini protocol describes a network software architecture where plug-n-play devices connect into a self-aware environment. The resultant system functions seamlessly as a single entity or "federation" that is dynamic and independent of the underlying platforms.

Jini is an open architecture specification built on top of Java™, a platform independent, interpreted software language developed by Sun Microsystems. Java is an object-oriented language widely used for applications distributed over networks. Jini is a well-defined set of secure protocols that allows a device to discover, join, and share services with other Jini enabled devices attached to the network. When a Jini device discovers and joins a network, specific data objects and programming services are made available to other devices on the network. A Jini enabled network is easy to install, maintain, and upgrade as it is based on a well-known commercial standard.

Third parties were slow to adopt Sun Microsystem's original Jini implementation due in part to criticism that is was too large, complicated, and expensive for small embedded devices. This created fear that the embedded Java community would eventually be forced to diverge from the intended spirit of the language and produce any number of splinter, non-compliant implementations. The licensing model and costs were also impediments to the wide spread acceptance of Jini. Sun Microsystems has responded by changing the distribution of Jini to their Sun Community Source License, a model that encourages third party collaboration and enhancement of the technology. The result is that Jini developers in common industries are now working together on code extensions and lookup service specifications that will allow their products to interact in a Jini

federation. Jini extensions developed within the bounds of the new license model have the potential to be included in Sun Microsystems' Jini core language specification if they are deemed fit by an oversight committee and useful to the community at large. The changes to the Jini technology license strategy have increased the chances that multiple vendors will supply Jini based product solutions that are plug-n-play and functionally compatible. The new model has also served to lessen the perceived corporate risk once associated with developing extensions on non-proprietary platforms. As a result, some of the largest and oldest companies in the computer industry have embraced Java and the concept of open-source, platform independence.

The device and system networking markets are growing rapidly due in part by the microelectronics revolution, the need to automate for efficiency, and the ability to interconnect systems running on a variety of platforms. A Jini complaint real-time communication extension could be leveraged into non-military applications that could benefit from plug-n-play connectivity, distributed processing, a decentralized network, and the flexibility to specify across multiple vendors.

3.1 Background

There is a tremendous need in the commercial marketplace for reliable communication networks and protocols that provide universal, spontaneous plug-and-play connectivity of diverse systems. The typical network installation has evolved over time. Upgrades are generally done piecemeal since the capital expense and service downtime prohibit "fork-lift" style upgrades. As a result, most communication networks contain equipment from multiple vendors with a variety of end nodes and gateways that have specific functions and unique commissioning requirements.

When new nodes are attached to a traditional network infrastructure it usually requires the resources and collaboration of multiple parties and the supreme oversight of the network administrator who must alter the network configuration information located in one or more servers. Even when the media and protocols agree, it is still an expensive proposition to determine the ultimate impact on the entire network and design in new equipment that can share information at the application level. The end result is that many communication networks are designed, installed, and never change from their initial implementation due to the poor return on investment.

The state-of-the-art in communication networks is changing at a rapid pace. Most of the emphasis has been in the connectivity, bandwidth, and data type arenas. Solutions for physical connectivity have become basic commodity items due in part by the proliferation of the Internet into the office and home space. This has resulted in the widespread availability of low cost Ethernet interface hardware and plug-and-play software that makes it easy to interconnect common personal computers. Network technologies like broadband and microwave communication satellites have increased the available bandwidth to the point where dissimilar data types can now be carried side-by-

side over general-purpose backbones. This allows networks based on TCP/IP, ATM, and proprietary protocols to carry computer data, voice, and video over a common communications channel.

The most significant advancement in network technology has been the ability to interconnect dissimilar systems and platforms over a common architecture. The OSI networking stack models are inherently independent of the operating system running on any given node, but it falls short of specifying how these systems intercommunicate at the application level. Consequently, the sharing of data and resources between dissimilar platforms remains a technological challenge. There are too many differing architectures and operating systems to make a low level solution realistic.

The solution is to utilize a common language over the network and have each system interpret these commands and translate them into their own native instruction set. Java is an object-oriented software language developed by Sun Microsystems, Inc. which addresses the need for a platform independent language that can be securely distributed over a network. Java is a relatively young language, but in a very short time it has become the language of preference for distributed graphical user interfaces as well as server side network application programming.

Java is architecture neutral. The only requirement is an interpreter, or Java Virtual Machine (JVM) that translates the Java object code into routines that the machines native instruction decoder can process. Java is a modular language and it is easily scaled to fit within the resource bounds of most any embedded system. The JVM deployment in any given system will vary according to the resources available.

The programming methods found in a desktop personal computer's JVM will have routines that take advantage of the system's keyboard, monitor, mouse peripherals, and relatively large memory. Conversely, a small embedded system designed to perform a dedicated data acquisition task may have a very limited memory and no resources for a user interface. The embedded system JVM would only include the methods necessary for the system's limited resources and specific functions required to run its intended application task. Both systems are capable of running Java software which opens the opportunity to share on-line data objects and code written for no particular platform, executable code, and code that will be interpreted to their respective native operating systems. Java alone does not alleviate the task of configuring the network every time a new device is attached, but it does provide a mechanism to communicate and run a common instruction set in a network.

3.2 Jini Software Platform

The Java programming language provides an ideal framework for a network based distributed system that is capable of interconnecting devices free of any architecture or resource constraints. Jini is a software system with a Java extension that allows a device

with a JVM to be networked into an environment with a plurality of autonomous nodes that function as one entity called a federation. A Jini federation is a dynamic, plug-n-play environment that consists of any number of nodes that work harmoniously sharing data and code.

Jini enabled devices accomplish plug-n-play functionality by a process called *discovery* and *join*. During the discovery process the device locates one or more available lookup services. A lookup service is an enumerated list that contains information about the types of services available throughout the federation. During the join phase the device registers its own services, making them available to any other Jini-based devices within the federation. The information located in the lookup service includes everything necessary for a peer to interact with the functionality and attributes of a given Jini enabled device. This includes details such as callable interfaces, object arguments, and even executable code. Once a Jini-enabled device joins and discovers a federation it has the ability to interact seamlessly with other devices located on the lookup service.

The Jini software platform provides all the mechanisms necessary to implement a self-aware distributed processing network, however it does not specify industry specific service interfaces. This task is left to clusters of industry specific groups who find it mutually beneficial as a means to provide interoperability. Companies involved in everything from automotive components to health care logistics are collaborating to provide Jini-based products and solutions. The scalability and extensibility of Jini makes it possible to provide industry specific services that ultimately allow plug-n-play compatibility between products and systems produced by multiple vendors. Jini is very dynamic software technology in that it provides a mechanism to develop functionality tailored for a specific industry.

The challenges of integrating inter-subsystem communications over any network topology include security, latency, and fault tolerance. Jini technology allows the developer to define the details of the service interfaces and functionality. This is an ideal framework for any developer attempting to meet industry specific requirements. The challenges of the proposed network architecture and software API are not unique to the United Stated Navy. The industrial automation and control marketplace would also benefit from a plug-n-play communication technology that provided for secure, real-time, mission-critical functionality, and possibly become part of the core Jini software language specification.

4. PHASE I TECHNICAL OBJECTIVES

The overall objective of the proposal is to develop a network architecture that leverages Jini technology to provide a dynamic plug-n-play solution to inter-subsystem communication. The resultant network topology would provide a basis for connectivity between heterogeneous platforms, new and old. The specific objectives of the program can be enumerated as follows:

1. Establish a minimum set of network throughput and resource requirements for a secure, real-time, mission-critical device network using Jini technology concepts. These requirements will be used throughout Phase 1 to determine the suitability of any existing or proposed technology.
2. Research relevant work in the area of Jini real-time, mission-critical control applications that is within the bounds of the Sun Community Source License (SCSL). Characterize and catalog the merits of any Jini extensions or individual components within an extension as to their applicability into a secure, real-time, mission-critical network.
3. Create an object-oriented schematic of the network architecture required to implement secure, real-time, mission-critical functionality as Jini-based services.
4. Develop requirements for the individual methods needed to implement secure, real-time, mission-critical services as an extension to the base Jini platform. Organize the methods as an autonomous Application Programming Interface (API) that is an extension to Jini. Document the proposed software extension using standard Java documentation methods or JavaDoc.
5. Code the individual software methods required to implement the secure, real-time, mission-critical service extension. Verify the operation of each software module. Integrate and package the new API as a portable Jini extension.
6. Demonstrate a secure, real-time, mission-critical control system using a Jini enabled device network with the new API. The resultant prototype system will demonstrate a classical control loop operating over a distributed plug-n-play network. The demonstration will include operation over a TCP/IP local area network (LAN) as well as the Internet.

5. PHASE I - WORK PLAN

The Phase I work plan will include the following tasks for achieving the stated objectives:

5.1 Task I – Establish Network Throughput and Resource Requirements

The first task is to characterize the requirements of the overall communication system and establish goals for network throughput, security, and fault-tolerance. The requirements will be considerate but not constrained by the existing Jini software specification. Special consideration must be given to the following attributes:

1. Degraded modes of operation in the event of a missing or non-functioning device.
2. Data encryption methods.
3. Network and device health monitoring.
4. Decentralized network topology.

The requirements developed during this task will be used throughout the project to evaluate the merit of any individual component within the implementation as well as the final result.

5.2 Task II – Research Relevant Work in that Area of Jini Secure, Real-Time, Mission Critical Applications

The unique model of the Sun Community Source License has resulted in many cooperative endeavors to develop and deploy Jini technology. The "jini.org" web site is a collection of open-source projects aimed at advancing the technology and creating industry specific, plug-n-play solutions.

There are many projects that have attributes similar to the proposed project. During this task we will research any relevant work that could be leveraged into a secure, real-time, mission-critical software API.

5.3 Task III – Create An Object-Oriented Schematic of the Proposed Network Architecture

During this task we will create a schematic and flow diagram of the proposed network architecture using object-oriented flow diagrams. This is a high-level diagram showing the flow of data objects necessary to meet the requirements developed during Task I.

The data transfers described in the flow diagram will be compartmentalized by function and sorted by priority. The individual functions will be used to describe services that must be performed or available to any given device on the network.

5.4 Task IV – Develop Requirements for the Specific Java Methods

This task takes the results of the object flow diagram and creates requirements for the individual Java methods necessary to mechanize the desired services. The Java method interfaces and code functionality will be described using one of the widely accepted documentation standards such as JavaDoc. These requirements will become the basis for the Java code necessary to implement the services in the target API.

Before any coding begins, the requirements will be evaluated for usability outside of the target application in inter-subsystem communication links.

5.5 Task V – Develop Code that Implements the Proposed API

During this task the actual API software requirements are translated into Java code. The individual modules will be tested for functionality and packaged together as an API that extends the core Jini technology.

It is anticipated that the resultant API will be suitable for inclusion in the Jini core language specification, but the process is beyond the scope of this proposal due to time constraints.

5.6 Task VI – Develop a Rapid Prototype Demonstration System

Develop a demonstration system using the newly developed API and commercially available equipment. The resultant prototype system will demonstrate a classical control loop operating over a distributed plug-n-play network. The demonstration will include operation over a tightly controlled TCP/IP local area network (LAN) as well as the Internet.

The prototype system will mechanize a temperature controller using autonomous nodes for the feedback and actuator functions. The system will include one heating element and two individual temperature sensors used to provide feedback. The system will be plug-n-play, self-aware, self-healing, and as Jini compliant as possible while still accomplishing the target goals of this proposal.

The prototype system will be able to demonstrate degraded modes of operation and all the requirements developed during Task I.

6. RELATED WORK

The Principal Investigator (PI) has been involved in the research, development, and deployment of hardware and software for network enabled embedded systems, including small implementations of Linux and Java Virtual Machines. The PI has developed network based monitoring and control systems using proprietary Java software running on miniature embedded web servers. At his previous place of employment, he was responsible for the conceptual design and support of ATM and TCP/IP networking components used in high-speed network switches. The PI is in close contact with other researchers developing Java based devices that communicate via TCP/IP.

The staff at Integ Process Group, Inc. has over 100 years of experience in the development, design, and maintenance of factory automation and control systems in the metals, transportation, and newspaper industries.

7. RELATIONSHIP WITH FUTURE RESEARCH OR RESEARCH AND DEVELOPMENT

There is a growing interest in TCP/IP enabled factory floor automation and control systems. In addition, the Internet has made it possible to interconnect local area networks at little expense. As a result, Integ Process Group, Inc. has been working to develop solutions that connect equipment to desktop web browsers. The commissioning and maintenance cost of any network device is still a barrier to entry in some markets, a problem that can be solved with plug-n-play device technology. The proposed Phase I work will determine the resource requirements and system throughput available with Jini technology.

8. POTENTIAL POST APPLICATIONS

There is a growing market for proxy devices that add network connectivity to legacy equipment and systems. Most legacy systems have proprietary, or outdated interfaces that require a bridge or proxy device to handle the requirements of the modern TCP/IP network.

The Integ Process Group, Inc. is involved in the definition and development of small embedded devices that connect analog and digital I/O points to desktop web browsers. A secure, real-time, mission-critical network communication architecture that leverages Jini technology has widespread application in the factory automation and control industry. It also has the potential of becoming a well defined and accepted standard for the network side of a legacy equipment proxy device.

9. KEY PERSONNEL

[redacted]

Systems Engineer

EDUCATION:

B.S., Electrical Engineering, University of Pittsburgh, anticipated 2001.

CURRENT POSITION AND RESEARCH:

[redacted] is a Systems Engineer with the Integ Process Group, Inc. He is responsible for the design of embedded hardware, software, and networking applications. He is currently working with miniature embedded web servers that are used to distribute process control and monitoring information over TCP/IP and ATM networks. He has more than 15 years of experience in the research and development of embedded systems and electronic products.

RELEVANT EXPERIENCE:

Prior to joining Integ Process Group, Inc, he was a founder, of [redacted], a start-up company that developed low-cost network interfaces for sensing systems and machines. There he was responsible the development and design of computer hardware, software, and communication networks. [redacted] has worked or consulted for the R&D departments at the following companies:

- [redacted] - ATM networking switches and access devices.
- [redacted] - Fail-safe embedded systems used to control rail systems.
- [redacted] - High-power motor drives and industrial controls.
- [redacted] - Embedded hardware and software used to interconnect devices and machines over TCP/IP networks.
- [redacted] Precision motion control products used in the semiconductor industry.

10. FACILITIES/EQUIPMENT

To support its current development activities, Integ Process Group, Inc. maintains a computer development laboratory and several TCP/IP networks. The computer lab includes desktop systems running Windows 2000, Windows NT, Windows 95, Linux, and VMS.

The TCP/IP networks that will be used to perform the work outlined in this proposal include two private local area networks and two public networks. Integ Process Group, Inc. currently owns 24 pubic IP addresses that are used to test hardware and software that operates over the Internet.

11. CONSULTANTS

No consultants are presently foreseen for the Phase I program. If a need should arise, Integ Process Group, Inc. has relationships with two consultants available from the facilities of the University of Pittsburgh, School of Computer Engineering.

12. PRIOR, CURRENT OR PENDING SUPPORT

Integ Process Group, Inc. has no prior, current or pending support for a similar proposal.

13. COST PROPOSAL

Please see the following pages.

14. COMPANY COMMERCIALIZATION REPORT

Please see the attached.

U.S. DEPARTMENT OF DEFENSE
SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM
COST PROPOSAL

Cost Breakdown Items

1 INTEG process group, inc.

2 [redacted]
Pittsburgh, PA [redacted]

3 Pittsburgh Office

4 Application of JINI Technology to Tactical System Integration

5 Federal Tax ID [redacted]
CAGE Code - N/A

6 N01-082 TITLE: Application of JINI Technology to Tactical System Integration

7 Total of Proposal [redacted]

8 Direct Material Costs

a. Purchased Parts	$0.00
b. Subcontracted items	$0.00
c. Other	$0.00
d. Total Direct Material	$0.00

9 Material Overhead Rate - 5% $0.00

10 Direct Labor

Person	Hours
a. Type of Labor [redacted] Systems Engineer	960
Principal Investigator [redacted] Systems Engineer	120

b. Total estimated Direct Labor

11 Labor Overhead

Person	Hours
a. Identify overhead rate, the hour base and dollar cost [redacted] Systems Engineer	960
Principal Investigator [redacted] Systems Engineer	120

b. Total estimated Labor Overhead

12 Special Testing
a. Provide cost for each item N/A
b. Estimated Total Special Testing $0.00

13 Special Equipment
a. If direct charge, specify item and cost N/A
b. Estimated Total Special Equipment $0.00

14	Travel (if direct charge)	
	a. Transportation	$0.00
	b. Per diem	$0.00
	c. Estimated Total Travel	$0.00
15	Subcontracts	
	a. Identify	None
	b. Estimated Total Subcontracts	$0.00
16	Other Direct Costs	
	a. Estimated Total Direct Cost and OH	[redacted]
17	General and Administrative Expense	
	a. Percentage rate applied	25%
	b. Estimated Total G&A Expenses	[redacted]
18	Royalties	
	a. Estimated Cost	N/A
19	Fee or profit	[redacted]
20	Total estimate cost and fee	[redacted]
21	Responsible Official	[redacted]
	Vice President	SIGNATURE
	January 8, 2001	DATE 1/8/01

22 Provide a yes or no answer to each of the following:

ANSWER	Question
NO	a. Has any executive agency of the United States Government performed any review of your accounts or records in connection with any other government prime contract or subcontract within the past 12 months? If yes, provide the name and address of the reviewing office, name of the individual and telephone extension
NO	b. Will you require the use of any government property in the performance of this proposal? If yes, identify.
NO	c. Do you require government contract financing to perform this proposed contract? If yes, then specify type as advanced payments or progress payments.

23	Type of contract proposed	Firm-fixed price

Company Commercialization Report
Summary Page

Firm Name: INTEG process group, inc.
Mail Address: [redacted]
Pittsburgh, PA [redacted]
Phone: [redacted]

Commercialization Achievement Index: N/A

This Index is a measure of how commercialization resulting from the proposer's prior phase II SBIR/STTR awards (from 1998 and before) compares with the commercialization resulting from groups of DoD SBIR/STTR projects selected at random from comparable time periods. (Commercialization includes both military and private sector markets.) The index score is a percentile ranking which ranges from 100 (highest) to 0 (lowest). Its statistical meaning is described in detail at http://www.DoDSBIR.net/Submission/CompanyCommercialization/Instructions/D

An Index score is only calculated for proposers that have received at least 5 phase II awards in years up to and including 1998.

Other positive indicators of this proposer's commercialization: *(The indicators that apply to this proposer are noted with a ✓ in the column marked "Applies?".)*

Applies?	
	The proposer's Commercialization Achievement Index is between 70 and 100. *(This indicator may potentially apply to all proposers that received one or more phase II awards in years up to and including 1998.)*
	The proposer has completed an Initial Public Offering ("IPO") of Stock that was the result, in part, of technology it developed under the SBIR/STTR programs.
	The proposer has experienced employment growth averaging 10 or more people per year since receiving its first phase II award.

(END OF SUMMARY)

Company Commercialization Report
Full Report and Company Certification

Commercialization Achievement Index:	**N/A**	
Phase I Awards:	**0**	Number of Employees in : **0**
Phase II Awards:	**0**	Current Number of Employees: [redacted]
Number of Patents resulting from SBIR/STTR:	**0**	
SBIR/STTR Funding as % of revenue:	**N/A**	
IPO resulting from SBIR/STTR:	**No**	

Certification by Proposing Company:

The information I have provided to DoD regarding commercialization of our company's prior SBIR/STTR awards is complete and accurate to the best of my knowledge. I understand that knowingly and willfully making any false, fictitious, or fraudulent statements or representations is a serious criminal offense.

FIRM CORPORATE OFFICIAL:

NAME: [redacted] TELEPHONE: [redacted]

TITLE: VICE PRESIDENT FAX: [redacted]

[redacted] 1/8/01

SIGNATURE OF FIRM CORPORATE OFFICIAL DATE