Introduction to Golden Gate

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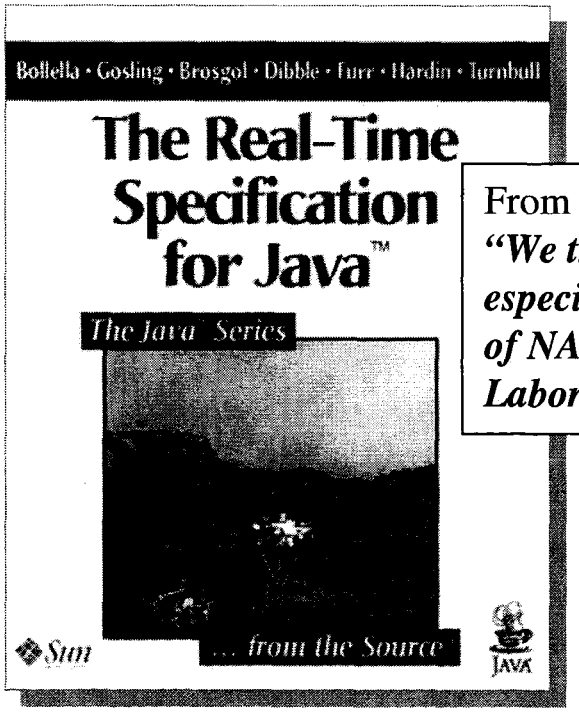
Project Golden Gate Team

JPL	Sun	Carnegie Mellon
Daniel Dvorak Vanessa Carson Alex Murray Kenny Meyer Kirk Reinholtz (MDS Staff)	Greg Bollella James Gosling	Virgil Champlin Brian Giovannoni

- Complimentary skills sets (Industry, Research, and Domain)
  - JPL
    - Domain Knowledge / OOP
  - Sun
    - RTSJ / Java
  - Carnegie Mellon
    - Embedded real-time
    - Java / Industry J2ME
- Highly motivated open door for new technologies: Java, RTSJ, Linux
  - Areospace is traditionally conservative

History of JPL/Sun Relationship
It all started back in '98

- November '98: MDS met with Sun Microsystems and WindRiver Systems to discuss the use of Java for flight software.
- February '99: JPL and Sun signed a Confidential Disclosure Agreement
- April '99: JPL, Sun and WindRiver engineers met at JPL to discuss technical details of using Java for flight software.
- May-September '99: JPL conducted an Java evaluation with support from Sun. The whitepaper was completed in early September '99
- September/November '99: Recommendations and white-paper delivered to Project and Institutional management
- November '99 thru Oct '02: JPL ran low-level Java Evaluation task
- June 2000: Real-time spec (JSR-1) published
- January 2001: JPL provided rover to Sun for CES
- Winter/Spring 2001: RTSJ test suite discussions (Sun/JPL/AFRL/Boeing)
- April-June 2001: Sun and JPL meet to discuss Strategic Alliance



From the preface…
"We thank all those, but especially Kirk Reinholtz of NASA's Jet Propulsion Laboratory …"

History of JPL/Sun Relationship
It all started back in '98

- August 2001: Sun and JPL pitched DARPA for MDS in Java
- Fall/Winter 2001-02: MDS engineers briefed Sun Labs and Architecture Tech Group
- March 2002: Letter of Intent signed, MDS/MSL topic in Gosling's Java One Keynote (Video clip)
- April 2002: JPL names Gosling and Bollella Distinguished Visiting Scientists
- July 2002: McNealy sends letter to McNealy, Baltimore, and Elachi
- September, 2002: MOU signed

Letter to Sean O'Keefe
from Scott McNealy (CEO, Sun Microsystems)

SEP. 9. 2002 10:57AM NO. 7760 P. 2

Sun Microsystems, Inc.
901 San Antonio Road, Palo Alto, CA 94303-4900

July 12, 2002

The Honorable Sean O'Keefe
Administrator
National Aeronautics and Space Administration
Washington, DC 20456-0001

Dear Sir:

I want to be certain you know about an important technical alliance underway between our organizations. For the past year, engineers from Sun Labs have been collaborating with engineers from JPL to create technology that will greatly benefit ...tion of our ...our latest

"...Golden Gate is among the most significant projects at Sun Labs."

...s. Our ...endable, ...ovides a ...revolutionary technology for software development for systems of sensors, control algorithms, and actuators. Together, these technologies enable Sun to press forward with our corporate vision for the next generation of post-internet products. The potential is great enough that our technical management has taken the extraordinary step of cross-licensing the associated technology from Caltech.

"...We believe this will be a major turning point in the history of space software."

...point in the history of space software.

Sincerely,

COPY

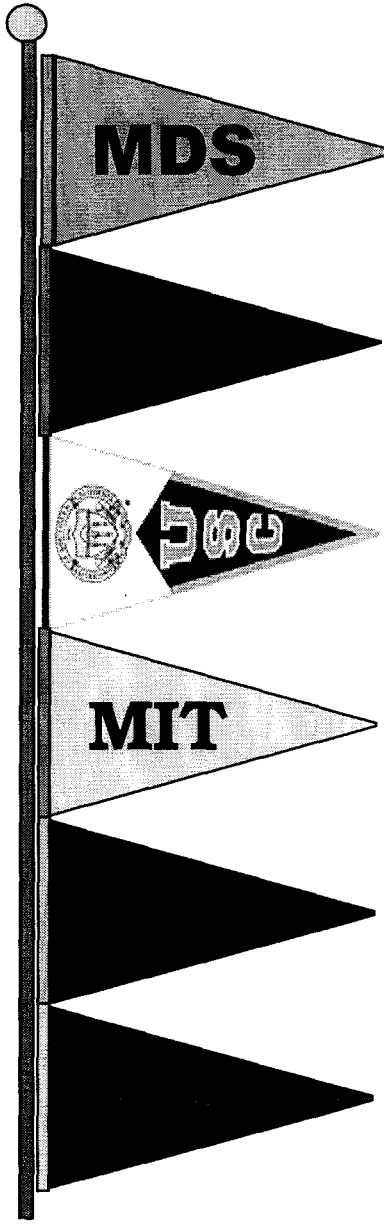
Scott G. McNealy
Chairman, President and Chief Executive Officer

SGM/k

cc: James Gosling
Greg Bollella

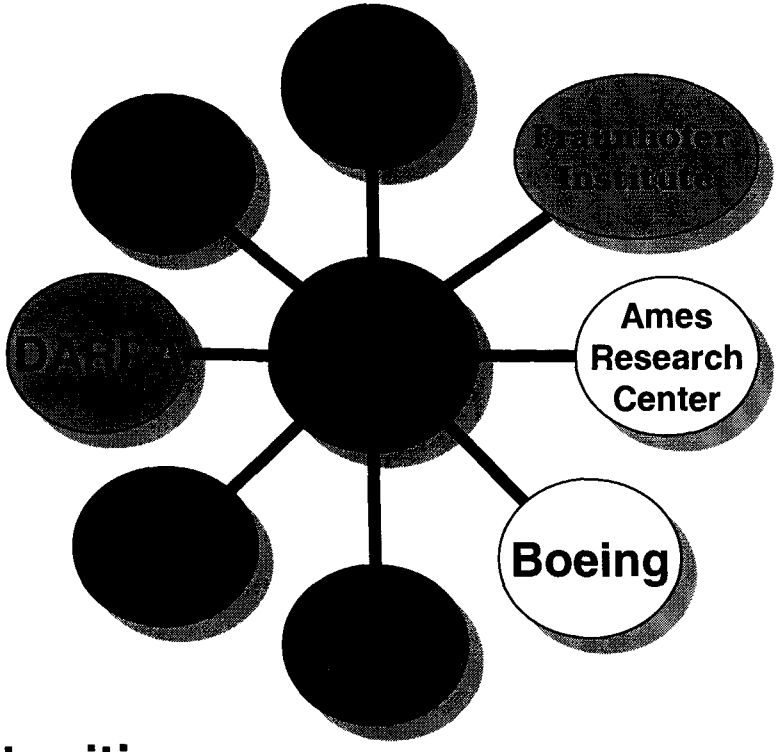
MDS selected as HDCP Testbed
High Dependability Computing Program

- **Current focus**: Development of dependable systems
- **Areas of interest**:
  - HDCP: MDS System Engineering, MDS architecture, MDS component technology, MDS development methods, MSL technology infusion
  - JPL: HDCP verification methodologies, component technology, cost modeling, defect modeling, formal methods, others
- **Sponsor**: NASA Code R, closely associated with NSF's HDSCCR Program
- **Collaborating organizations**:
  - Active: CMU, USC, Fraunhofer, Hawaii
  - Potential NSF-funded collaborations: Stanford, Berkeley, MIT, others
- **Significant active projects**:
  - USC SCRover Project, MDS-based generic-rover testbed for research, Barry Boehm PI
  - CMU/Sun Goldengate Project, MDS in Java, James Gosling & Greg Bollella, PIs
  - SEI dependability cases, MDS risk reduction, John Goodenough PI (Chief Technical Officer of the SEI)
  - CMU software architecture, MDS component technology, David Garlan PI
  - Hawaii process improvement, MDS processes, Philip Johnson PI
  - Goal-Question-Metric verification, MSL verification, Vic Basili PI



Carnegie Mellon University

- **Collaborators**
  - SEI (DoD FFRDC)*
  - Fraunhofer Institute (University of Maryland-base Research Center with ties to NASA)
  - Robotics Institute (Strong ties to DARPA)
  - Sun Microsystems
  - Other Silicon Valley companies (Oracle, Amazon, Microsoft, Intel, etc)
- **Agreements**: NDA, Use-licenses pending, MOU pending



"[The research agenda] has initially focused on...working with Sun Microsystems and the California Institute of Technology's Jet Propulsion Laboratory (JPL), to create a Java version of JPL's architectural framework for mission-critical, real-time control systems."

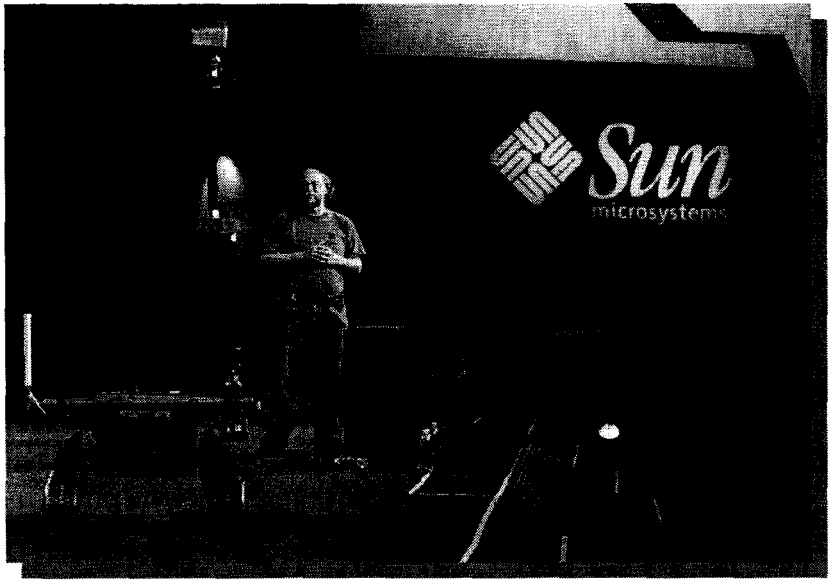
— CMU Founder's Day Press Release (12/20/02)

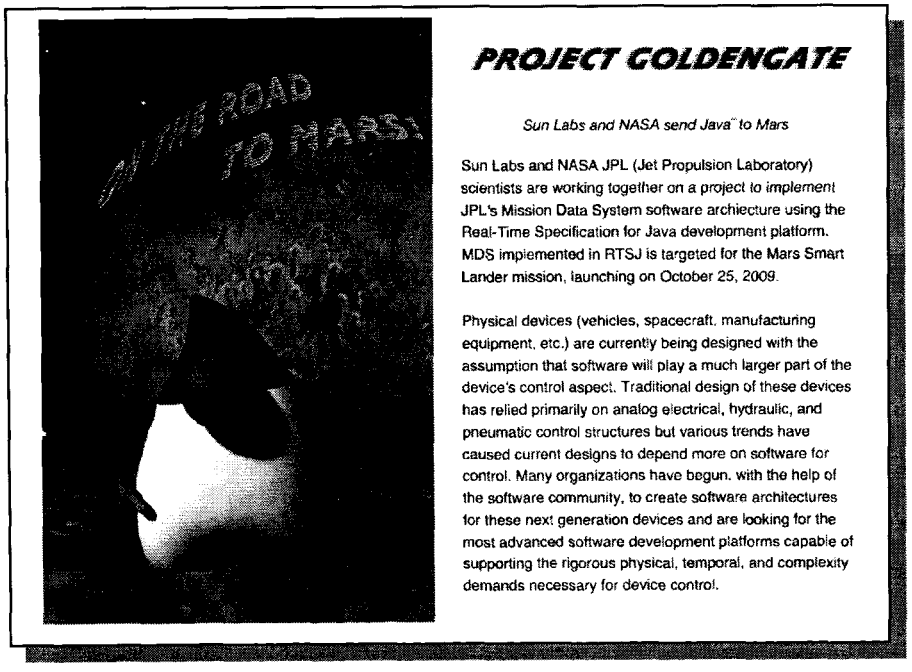
- **Opportunities**:
  - MDS master's program
  - Participation in MSL V&V effort
  - MDS education program for NASA and industry

* SEI developed and maintains CMM & CMMI

Progress to Date

- Summer 2002: MDS in Java design meetings with Gosling and Bollella
- September, 2002: SunNetwork keynote. (Video clip)
- October, 2002: Goldengate kickoff
- June 2003: JavaOne demo





PROJECT GOLDENGATE

Sun Labs and NASA send Java™ to Mars

Sun Labs and NASA JPL (Jet Propulsion Laboratory) scientists are working together on a project to implement JPL's Mission Data System software archiecture using the Real-Time Specification for Java development platform. MDS implemented in RTSJ is targeted for the Mars Smart Lander mission, launching on October 25, 2009.

Physical devices (vehicles, spacecraft, manufacturing equipment, etc.) are currently being designed with the assumption that software will play a much larger part of the device's control aspect. Traditional design of these devices has relied primarily on analog electrical, hydraulic, and pneumatic control structures but various trends have caused current designs to depend more on software for control. Many organizations have begun, with the help of the software community, to create software architectures for these next generation devices and are looking for the most advanced software development platforms capable of supporting the rigorous physical, temporal, and complexity demands necessary for device control.

Related Activities

- Open Forum kicks "Mission Critical/Safety Critical" profile effort
- Participation in JSR-50.

Technologies

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Golden Gate Goals:
Retire the Technology Risk

- Performance measurements
  - CPU usage
  - Throughput
  - Real-time response & timing jitter
  - Cache hit ratio
- Maturity of RTSJ and Linux/RT technology
- Multi-language development
  - How do Java and C++ work together?
- Application development effort
  - Time to development

A Few of the Attractions of Java

- Software Reliability / Maintainability
  - Currently used languages (C, C++) are complex and 'dangerous'.
- Simple Object Model
- Significant programmer productivity
  - Leverage tools and API
  - Standard class library includes collections, threading, networking and all other commonly needed capabilities.
- Automatic Memory Management
  (no memory overwrites, no dangling pointers)
- Highly Portable
  - Development can be done on many platforms
  - WORA

A Few of the Attractions of RTSJ

- Determinism
  - Spacecraft require strong deterministic guarantees and/or control for thread scheduling, synchronization overhead, lock queuing order, class initialization, maximum interrupt response latency, and GC characteristics.
  - real-time model for threads and async events
  - interfaces for scheduling parameters and feasibility analysis
  - support for hard-real-time tasks
- High-resolution time management
- Device Driver Portability
  - RTSJ provides access to OS resources

A Few of the Attractions of Real-Time Linux

- Highly reliable operating system
- Much more advanced than VxWorks
- Excellent real-time response
- Memory protection among processes

Approach

- Evaluate real-time Java against FSW demands
  - Target challenges cited in Nov. 1999 Nichols report "Using Java for Flight Implementation"
- Use MDS framework/code as a test bench
  - Same rover functionality as MDS/C++/VxWorks
  - Side-by-side performance comparison
- Leverage Distinguished Visiting Scientists
  - Dr. James Gosling, creator of Java, Sun Microsystems
  - Dr. Greg Bollella, lead of RTSJ, Sun Microsystems

Plan

- FY 2003:
  - Install Linux/RT and RTSJ JVM on Rocky7
  - JavaOne Demo
  - Run AFRL/Boeing test suite for RTSJ
  - Prototype, run, and measure major MDS components
- FY 2004:
  - Extend to run full MSL test scenario on Rocky7
  - Compare performance to C++/VxWorks version
  - Complete evaluations on latest product release