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Proposal for an SSC Detector Software Subsystem

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1. Project Definition

The purpose of this proposal is to advance understanding of how to build the large, intercommunicating, software systems needed to meet the computing demands of SSC detector design. To explore this problem, we propose construction of an advanced detector design and simulation environment using software technology expected to be widely available by the mid 1990's. The environment will support a mechanism through which software components can interoperate. This "software bus" is to be developed in close collaboration with the SSC Laboratory's Accelerator Division, with the Particle Tracking and Calorimeter studies at FSU and Martin-Marietta Astronautics, and with the Open Software Foundation. The bus will make it possible to integrate a variety of existing simulation software and other software utilities into collections of cooperating processes. It will also make it easy to replace individual software components as more suitable alternatives become available. It will facilitate building systems as a collection of cooperating tasks, rather than as large monolithic systems. The architecture will make it easier for developers to work in parallel at different sites, because it will enforce the early definition and use of high-level, standard interfaces.

The following interoperable components will be constructed:

(1) A "software bus" to provide the interoperation mechanism among components.

This will allow simulators to be easily replaced with real-time data collection systems, and will allow CAD/CAE systems from different manufacturers to be interchanged.

(2) A mechanism for easily changing the granularity of detector geometry, and coupling this to the appropriate physics codes.

(3) A high speed particle transport algorithm capable of running on both distributed and highly parallel architectures.

These applications will serve as prototypes for the advanced computing tools that will be needed for the design and development of the SSC detectors. They will run on all the common computing systems in the HEP community, and will be easily accessed and installed through a variety of national and international networks.

Each developed component will be accompanied by a set of planning documents that specify at the outset what is to be done, why it is needed, when it will be completed, what it will cost, and who will do the work. These documents will also specify the tests required to demonstrate that a given component meets its specified requirements, and the schedule to be followed during construction. The development approach is the same as the SSC Magnet Test Laboratory's Integrated Scientific Tool Kit project. A sequence of prototypes will be developed quickly to be used and evaluated by participating physicists and engineers. Feedback from this process guides the next round of development. This relatively formal approach is not usual in the HEP community, and thus should be considered an experiment in its own right. Part of the benefits of the project will be to evaluate the utility of modern software management techniques for HEP.

1.1 Background

Over the lifetime of SSC detector development and operation, the available computing environment will change dramatically. Most likely, the drift away from huge, centrally located, general purpose computer centers towards distributed collections of powerful workstations will continue. As a counter trend, large special purpose hardware, such as massively parallel machines for shower simulation or high performance database servers, probably only will be available at a few major installations.

To tie these trends together requires, of course, high-performance networking hardware, but equally as important is a high-performance software integration standard. It is the goal of the software bus to provide such a standard. With the bus

in place and tools written to its specifications, centralized servers can accommodate new types of workstation clients with no modifications required. Workstation applications can use servers regardless of what operating systems each uses or where the server physically is located, and improved versions of software modules can be incorporated into the distributed system with no changes (other than performance) to other components. Commercial software busses are expected to be widely available by the mid 1990's.

Having such flexibility will be vital to the SSC software efforts. Software costs are primarily people costs and as such can readily run to $100M for SSC detector codes. Each 1% improvement in programming productivity means $1M saved. The most dramatic improvement in productivity can come from eliminating tasks altogether. For example, the ability of the software bus to isolate servers from the details of their clients allows the latest hot workstations to be introduced with no server software maintenance at all. The cheapest jobs are those which don't exist.

1.2 Relevance to potential SSC experiments

The tools to be developed will use the Solenoidal Detector experiment as a proving ground, but must be easily adaptable to other detectors. The software requirements of the Solenoidal Detector will drive this software proposal, and the success of the software effort will be determined, in part, by the utility of the tools and their performance in that context.

However, considerable effort will be devoted to broadening the utility of the particular tools constructed and of the techniques used to develop and implement them. For example, these tools will be implemented using a "software bus." This technique implies considerable independence of software modules along with great flexibility of the system. If successful, this will mean that a different detector geometry can be tried with no impact on the simulation code, and models of new types of detectors can be added to the system with no changes to existing modules. This should enable these tools, developed originally for the LBL effort, to be used readily for other detectors and demonstrate the general effectiveness of the software bus concept.

In addition, the tools discussed in this proposal will be developed for a heterogeneous mix of hardware platforms by a collection of people at widely dispersed locations. This situation models that of the large collaborations expected for the SSC experiments. Modern software management techniques will be applied

to control and monitor the various phases of development, so that this project will be a test case to judge the effectiveness of state-of-the-art software practices for SSC experiments.

1.3 Scope

Design and development effort is expected to take three years at an effort level of two FTE software engineers. The project will require some subcontracting of software R&D. The project will also require purchase of a variety of commercial software packages compatible with the anticipated environment. It may also require investment in an advanced parallel processor (for high-speed particle tracking), and in high-performance graphics stations for visualization of particle simulations and detector geometries.

1.4 Project Outline

The project will proceed in five phases:

Phase I will take six months to complete and will produce a set of bus requirements to support the application areas. It will also produce a detailed implementation plan for Phase II. This plan will be reviewed before starting Phase II in May 1990.

Phase II will take six months to complete and will produce feasibility demonstrations of the proposed components. It will further establish a detailed plan for Phase III which will also be formally reviewed.

Phase III will also take six months to complete and will produce a working prototype of key components and a reviewed plan for Phase IV.

Phase IV will take about a year to complete and will produce the production system. A project evaluation will be produced summarizing experience with this form of software development.

Phase V will last for the lifetime of the SSC detector and will deliver ongoing maintenance and improvements to the system. This service will be provided by the Argonne center.

1.5 Preliminary list of components

(1) *A software bus.* The software bus will provide the basic mechanism for software to interoperate. It will include both a data sharing mechanism, quite possibly the Self Describing Data Standard (SDS) developed by the SSCL, and a software distribution mechanism, possibly the one currently under development at the Open Software Foundation.

(2) *Integrated CAD/CAE packages.* These will include the CAE/CAE 3D package developed by Martin-Marietta (and other commercial packages such as Autocad), interfaced to the software bus. This effort will be carried out in close collaboration with FSU and the vendors.

(3) *A mechanism for easily changing the granularity of a simulation both in terms of the detector geometry and the particle interactions.* We propose to extend the work of Womersly *et al.* at FSU to create a simulation environment, based on the software bus, that would allow a common detector definition to be used at various resolutions, definable at run-time.

During the evaluation of a detector design, a detector simulation package can be used at very different levels of resolution. Checking for leakage of energy into cracks between a barrel calorimeter and an endcap as a function of event vertex position can be done with a rather crude simulation, whereas detailed mapping of response variation due to uninstrumented supporting struts may need highly detailed work. In the past, independent simulations commonly were used for these different resolutions and they often did not agree, even at the level of the geometry definition.

(4) *A high performance particle transport program.* This will consist of a new, highly parallel, algorithm for simulating the transport of particles through a limited set of detector geometries, implemented and tested on distributed machines as well as an advanced parallel system such as the Connection Machine or the MasPar. It is aimed at achieving a major performance breakthrough in detailed shower simulations for SSC detectors.

The most detailed and accurate shower simulations involve tracking each secondary particle through the detector. This is usually a painfully slow process, and many careful simulations are not done because of computing resource constraints. With the increased cost of SSC detectors, these simulations must be done to verify hardware designs before they are built. On the other hand, the

higher energy of the interactions make the simulations even more tedious. The only resolution of the conflicts at present appears to be the use of new, massively parallel and distributed computing hardware. We propose to investigate commercially available hardware, and adapt a shower code to the parallel approach. The resulting shower server will fit into the software bus architecture and be available to those physicists who lack local access to a parallel computer.

2. Project Schedule

The following diagram shows the major tasks and milestones of the entire project. Each phase specifies a detailed plan for the following stage. This plan, together with the milestones are reviewed as part of a "go-ahead" decision for the next phase.

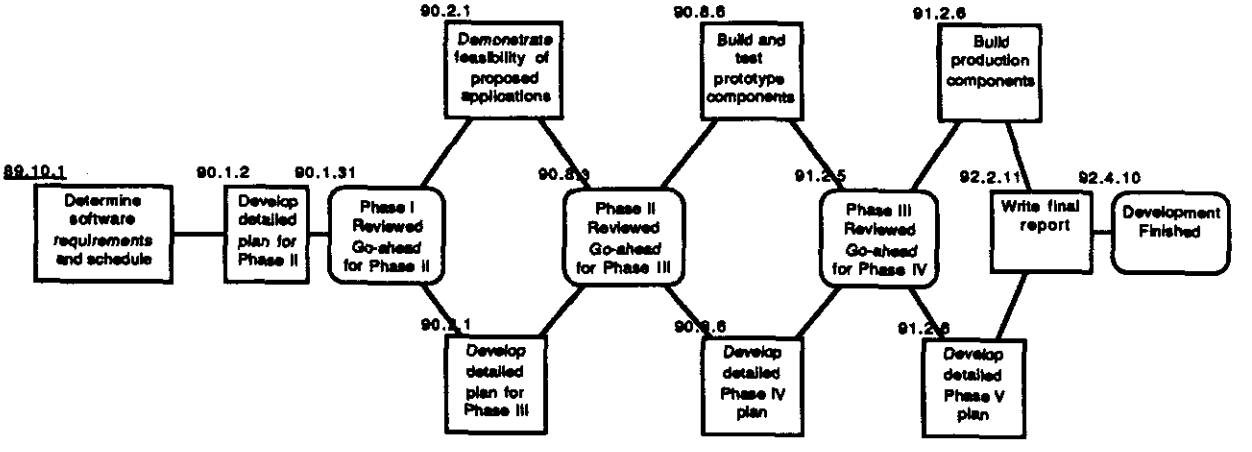

Figure 1 - Project Schedule

3. Project Budget

Task	Duration	Travel	Effort (2 LBL FTEs)
Phase I	6 months	$10K	$197K
Phase II	6 months	$10K	$197K
Phase III	1 year	$20K	$394K
Phase IV	1 year	$20K	$394K

4. Project Organization

4.1 Organization Chart

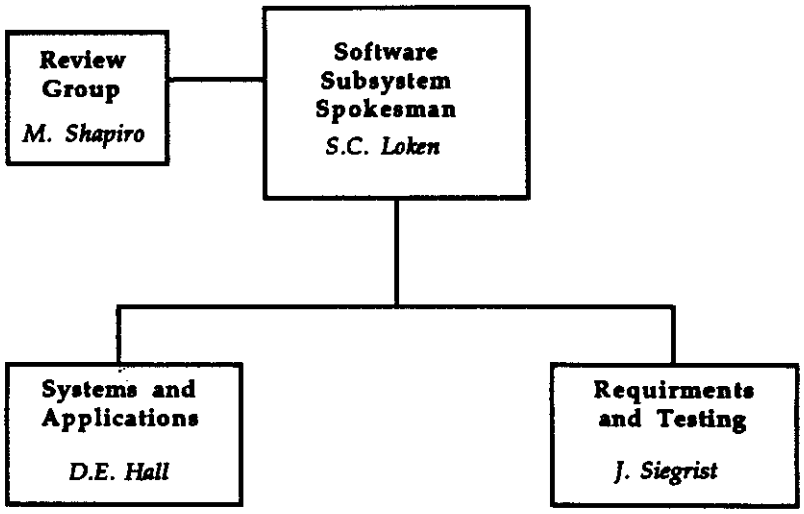

Figure 2 - Project organization

4.2 Responsibilities

Spokesman: The software subsystem spokesman is the key individual responsible for achieving the technical, cost and schedule objectives of the project. He is responsible for organizing, managing, controlling and reporting progress to the funding agency. The spokesman for this project will be Stewart Loken, of Lawrence Berkeley Laboratory.

Review Group Chairwoman: The Review Group Chairwoman is responsible for conducting formal reviews to demonstrate that both the scientific and technical goals of the project are met, and to make suggestions for corrections when they are not. She serves as an advisor to the project spokesman. The review group chairwoman for this project will be Margie Shapiro of Harvard.

Systems and Applications: The head of Systems and Applications reports to the project spokesman, and is responsible for the day to day management of

development effort. He is further responsible for preparing material for all reviews, and for issuing the regular project status reports. The head of Systems and Applications for this project will be Dennis Hall of LBL.

Requirements and Testing: The head of Requirements and Testing is responsible for ensuring that the requirements of the user community are met and for ensuring that the developed products meet these requirements. He works closely with the head of Systems and Applications to both determine the requirements and to specify the tests required to determine that these requirements are met. He advises the spokesman on these matters. The head of Requirements and Testing for this project will be James Siegrist of LBL.

4.3 Participants

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