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Virtual Global Accelerator Network (VGAN)

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Abstract: *The concept of a Global Accelerator Network (GAN) has been proposed by key members of ICFA as a cornerstone of a future International Linear Collider. GAN would provide a tool for the participants of an international collaboration to participate in the actual running of the machine from different parts of the world. Some technical experts view the concept as technologically trivial, and instead point out the significant sociological organizational and administrative problems to be surmounted in creating a truly workable system. This note proposes that many real issues can be explored by building a simulator (VGAN) consisting of a virtual accelerator model, a global controls model, and a functioning human organizational model, a tool that would explore and resolve many real problems of GAN and the LC enterprise during the LC preliminary design and testing phase*.

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The concept of a Global Accelerator Network (GAN) has been proposed by key members of ICFA as a cornerstone of a future International Linear Collider (LC). GAN would provide a tool for the participants of an international collaboration to participate in the actual running of the machine from different parts of the world. Some technical experts view the concept as technologically trivial, and instead point out the significant sociological, organizational and administrative problems that must be surmounted in creating a truly workable system. This note proposes that many real issues can be explored by building a simulator (VGAN) consisting of a virtual accelerator model, a global controls model, and a functioning human organizational model, a tool that would explore and resolve many real problems of GAN and the LC enterprise during the LC preliminary design and testing phase.

What is a meaningful test? Several people have suggested running an existing machine remotely as a test of the concept of GAN. Unfortunately such a test is relatively trivial to demonstrate, and in fact it has been pointed out that some models already exist, such as a Saclay link to control HERA. Others point out that the accelerator control room in most modern accelerators could be placed anywhere and still work more or less the same. Still others point to the astronomical observatory model where experimenters operate telescopes and collect data from home base. The value of these examples is that they provide encouragement that GAN is a viable idea, but they do not advance the modeling of the real problems of an LC. A meaningful test should in fact be based on a close technical model of an LC, a controls strategy, an operations and a maintenance strategy. Let’s discuss these in turn.

Modeling the LC: A virtual controls model is conceptually simple, but can be made arbitrarily complex. It could crib panels from existing machines, e.g. SLAC, DESY and KEK, to represent different subsystems, simply to avoid building everything from scratch. These subsystem models could be fed simulated real-time data representing the preparatory and start-up conditions of the machine, starting with securing the areas, enabling utilities, vacuum pump-down, turning on power supplies, injecting test bunches, threading the beam, finding the Gold Orbit, setting beam-based alignment, closing feedback loops, establishing beam delivery and collisions, and tuning for luminosity. The entire model can start very simply and grow as people become more inventive, striving to establish the “look and feel” of a real machine. The enterprise will take a large number of people, but fortunately it is divisible into many pieces, which is an opportunity to bring in new collaborators especially from among young physicists, university students and researchers.

Controls Strategy: The concept is to take pieces of existing controls packages and set up a new control system. It does not have to be a radical new design; it can take some well-tested pieces from existing designs. The machine might even be modeled as a hybrid of cold and warm technologies, to expand the value of the modeling and avoid squabbles over choices. At some point there is a very real problem of integrating all the pieces into a sensible controls model that relatively untrained people (not necessarily physicists) can learn to operate as part of a round-the-clock operation. This involves real computers located at a central site and/or distributed sites. It would be interesting to explore various architectures wherein certain sections of the controls model (i.e., subsystems) could be built and maintained at various sites, without compromising the overall real-time response of the model. This will work with some things but not with others where fast response is vital, e.g., machine protection. In the process of deciding how to put such a system together, the vital communications of a collaborative effort must be undertaken. Casting the problem in terms of actually building a model will help focus discussions, and putting it into a set of objectives and a timeline will force project-like decisions that will be extremely valuable. The most important part of this exercise is that it will force participants to come to rapid decisions and actions as needed to advance the LC, which would be strong evidence that an LC collaboration can succeed. Alternatively, endless discussions and airing of opinions and squabbles about the details of how things should be done, will quickly signal poor prospects for an international LC collaboration. GAN, or VGAN, is therefore an early test of the community leadership's ability to form consensus that is critical to progress.

Operations and Maintenance: Everyone seems to agree on a model where a number, say three, of different control sites will share operational duties on a twenty-four hour basis. If the concept works, by the way, there is nothing magic about the number three, and there is no reason why each of the three could not have satellite centers. What is the point of operation via GAN? The international collaboration of shareholders and stakeholders of the enterprise all have to be satisfied with their potential return on investment to gain their ultimate participation. CERN is the best model to point to because both machines and detectors are built collaboratively, and those involved in building both machines and experiments have opportunity for continuous future participation, as machine physicists and experimental physicists. The LC, however, calls for a higher level of collaboration in sharing of initial construction costs than any large accelerator attempted to date, so it seeks an appropriate new model of shared participation. Behind the concept of operators sitting at sites A, B and C sharing the day-to-day running, is the concept that engineers at sites A, B and C (and their close affiliates) will have designed and supervised construction of major sections of the machine, will have participated in installation and commissioning, developed controls and maintenance strategies, helped train on-site people in their controls and maintenance duties, and will continue to carry an engineering responsibility for the subsystem into the future. Accelerators are well known to evolve throughout their lifetimes. In addition, presumably the stakeholder regions will continue to provide a share of the operations funding of the parts of the machine and detectors that they have designed and built.

In VGAN, the objective is to simulate real machine operations, and real machine problems. The model would include *reliability* and an overall *availability* model.

Reliabilities can be calculated and a random number of failures of certain elements (vacuum pumps, water leaks, gauges, magnets, modulators, klystrons, BPMs etc.) can be programmed into the model. Redundancy in the accelerator model enables the virtual accelerator (VA) to keep running in the presence of certain faults, but others will be “single point failures” that will require immediate intervention. The overall *availability* of the machine, which is what counts in beams production, can be kept high only if effective *maintenance strategies* are in place that keep the *mean time to repair (MTTR)* to a minimum targeted number. All of these factors can be modeled and the GAN experimenters can not only become familiar with dealing with them, they can learn the weak points of current designs and provide valuable feedback to designers before the full machinery is actually designed and built.

Sociological Issues: Clearly language and cultural barriers need to be hurdled to make GAN work. Fortunately the technology itself is the bonding agent that makes it feasible to approach the issues. VGAN will immediately force an exercise where choices have to be made about communication tools, language or languages that will be supported, documentation standards, ability to transfer data and CAD files easily between groups, disciplines for engineering standards and controls to regulate the project. In facing such basic problems at an early stage, VGAN will enable the process of communication to the intense levels needed if a truly International Linear Collider is to become a reality. VGAN does this at a conceptual design level so that relatively modest extra funding is needed only for computers and simulated control rooms. Finally, VGAN can be advanced by a collaboration of existing controls and machine physics groups with, one hopes, strong collaboration by young physicists and new university collaborations involving students and their professors. Because of its scope and longevity both in building and operating, it is vital that many new intellects become engaged and trained during this conceptual design experiment.

The Operations Scenario: Prototype scaled-down models of control rooms would be built at three sites, each possibly extended to satellite sites. They would communicate over GAN with the Virtual Accelerator at a fixed (fourth) location. A formal organizational structure would coordinate a simulated 24/7 operation. The simulation would be made as real as possible, supported by views of the physical site and communication with a “local” maintenance and support staff. The maintenance and support staff itself could in reality be set up at or near the regional control centers, with well-defined responsibilities for major sections or subsystems of the machine. This would simplify interfacing by limiting the number of people who have to communicate to a top operations supervisory staff. Obviously the organizational model has many possibilities and demands careful study. The exercising of a support and maintenance staff is very important, first, to simulate diagnosis of problems, and second, to initiate the correct virtual repairs. The latter will consist of time delays for repairs according to an MTTR schedule (which could be complicated by multiple simulated failures at one time, or failures of diagnostics that make problem resolution difficult). The recovery scenario is to reestablish beam, feedbacks and tuning. Building in realistic recovery time constants, including recalibration of replaced parts is also important. Without belaboring the possibilities, the major goals are to test the organizational, operational, support, maintenance and sociological problems of the GAN concept. Finally, it is clear that human interaction, language and cultural barriers, multilingual management and organizational structure, are subjects of great interest to the fields of sociology, psychology and business management, and some researchers from these fields should be co-opted into the experiment.

Resources and Management: The development of VGAN will require support from a critical mass of physicists, machine physicists, engineers and programmers, plus a new infusion of support from university students and graduate students in physics, engineering and computer science disciplines. The funding for these people hopefully would come through directed funding from existing programs, where the VGAN problems are seen as sufficiently rich in research content to justify broad participation. Without this infusion, the challenge of building the LC during a decade of flat budgets for high-energy physics research may prove insurmountable. The participants then become an additional resource pool for the future fast ramp-up needed to construct the LC. Needless to say, the management of this enterprise faces challenges far beyond the usual small committee approach that we normally use to launch R&D projects. It has to adopt a project management mentality from the outset, but with the disadvantage of having loose control over the actual resources. Therefore it will have to rely heavily on convincing all university research collaborators to buy into the management model and learn to deliver product within costs and on schedule. There are many successful examples of this type of collaboration in programs such as the U.S. ATLAS detector project for the new LHC.

Summary: VGAN can be a tool to accomplish both an important technical demonstration, as well foster the technical and managerial team-building needed to advance the international Linear Collider, in a manner that minimizes costs and maximizes participation of the broad range of people concerned with all aspects of the machine. Interlaboratory sociological models for actual, functional prototype operations need to be demonstrated early, along with technical models. Even implemented on a modest scale, VGAN can be a valuable tool that will identify problems and point toward solutions. VGAN can also be an early test of technical and managerial leadership in the physics and engineering community. Many variants of VGAN are possible, which this note does not address. Ultimately, available resources and success in co-opting new collaborators with fresh young faces will determine what can and cannot be attempted. However, the work accomplished through a VGAN experiment will be not just a quick demonstration of technical feasibility, but a significant advance in the art of collaboration needed to make an international LC a reality.