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Project Integration Architecture

http://www.grc.nasa.gov/WWW/price000/index.html

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Project Integration Architecture (PIA) Oversimplified Nutshell

Project Integration Architecture (PIA) is a distributed, object-oriented, architectural framework that provides (in a machine-intelligible manner) for the generation, organization, publication, integration, and consumption of all information involved in any process.

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Project Integration Architecture (PIA) Synopsis

PIA is an object-oriented wrapping architecture that captures and encapsulates the entirety of the technology process.

1. All sources and sinks of technological information are conformed to a single, self-revealing architecture. Common tool sets are enabled.

2. The complete trail of technological investigation is captured producing an auditable record. Notations, logs, journals and the like may also be captured.

3. Through the technologies of self-revelation and semantic infusion through class derivation, applications may interact with each other to provide for automatic transfer of information. The *n-squared* integration problem is eliminated and automated teaming is enabled.

4. Because information is "self-aware" through its encapsulation in an appropriate object, it can provide functionality appropriate for its kind. For example, dimensional information understands its own dimensionality and automatically converts to the appropriate system when accessed. Further, dimensional information disallows all accesses that are not dimensionally sensitive.

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Key Object-Oriented Technologies Exploited by PIA

1. Self-revelation: Objects can reveal their kind and the extent of their content.

    1.1 Self-revelation of kind sets the expectation for the nature and content of an object.

    1.2 Self-revelation of content exposes the extent to which expectations are, in fact, fulfilled.

2. Semantic infusion through class derivation: By progressive derivation from parent to child, the nature of the derived child can be progressively defined.

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Engine Systems Technology Branch

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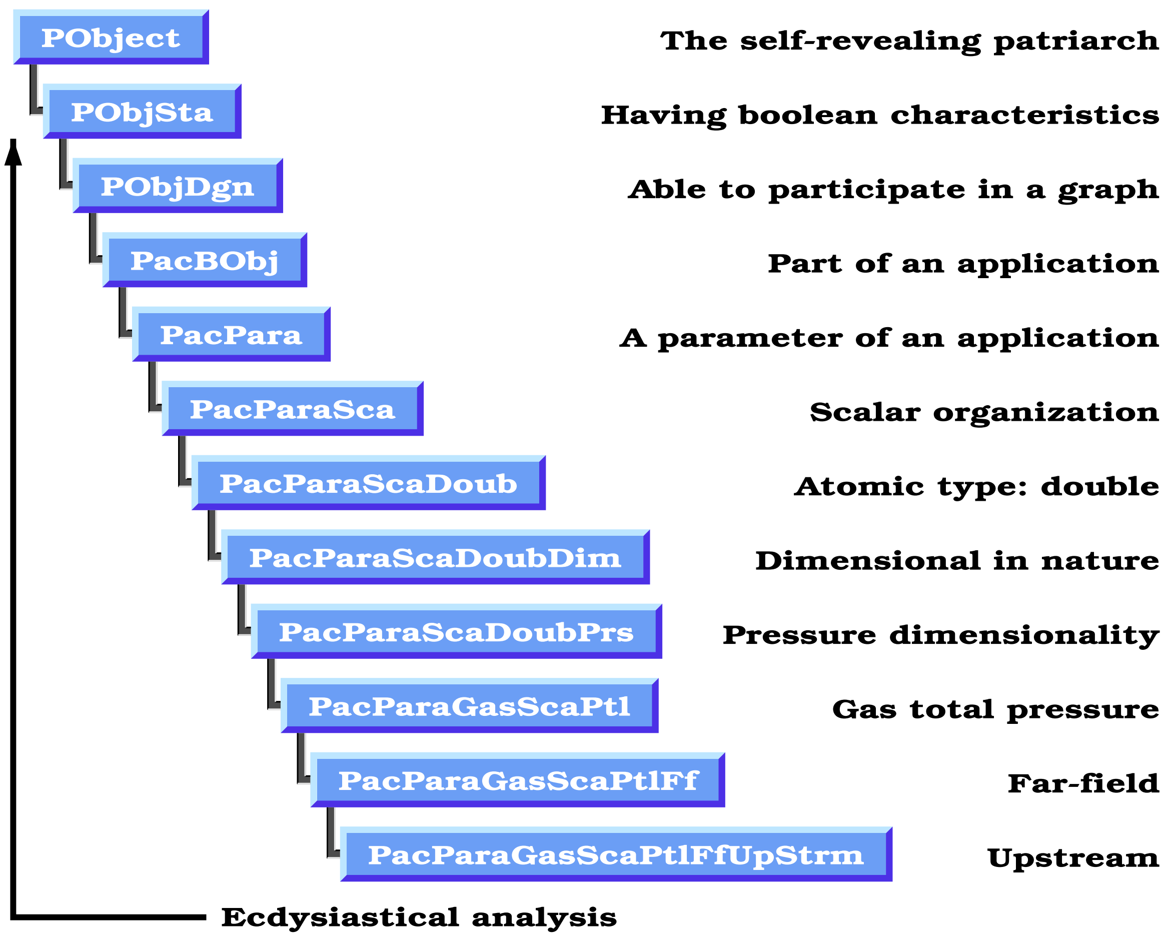

Semantic Infusion through Class Derivation

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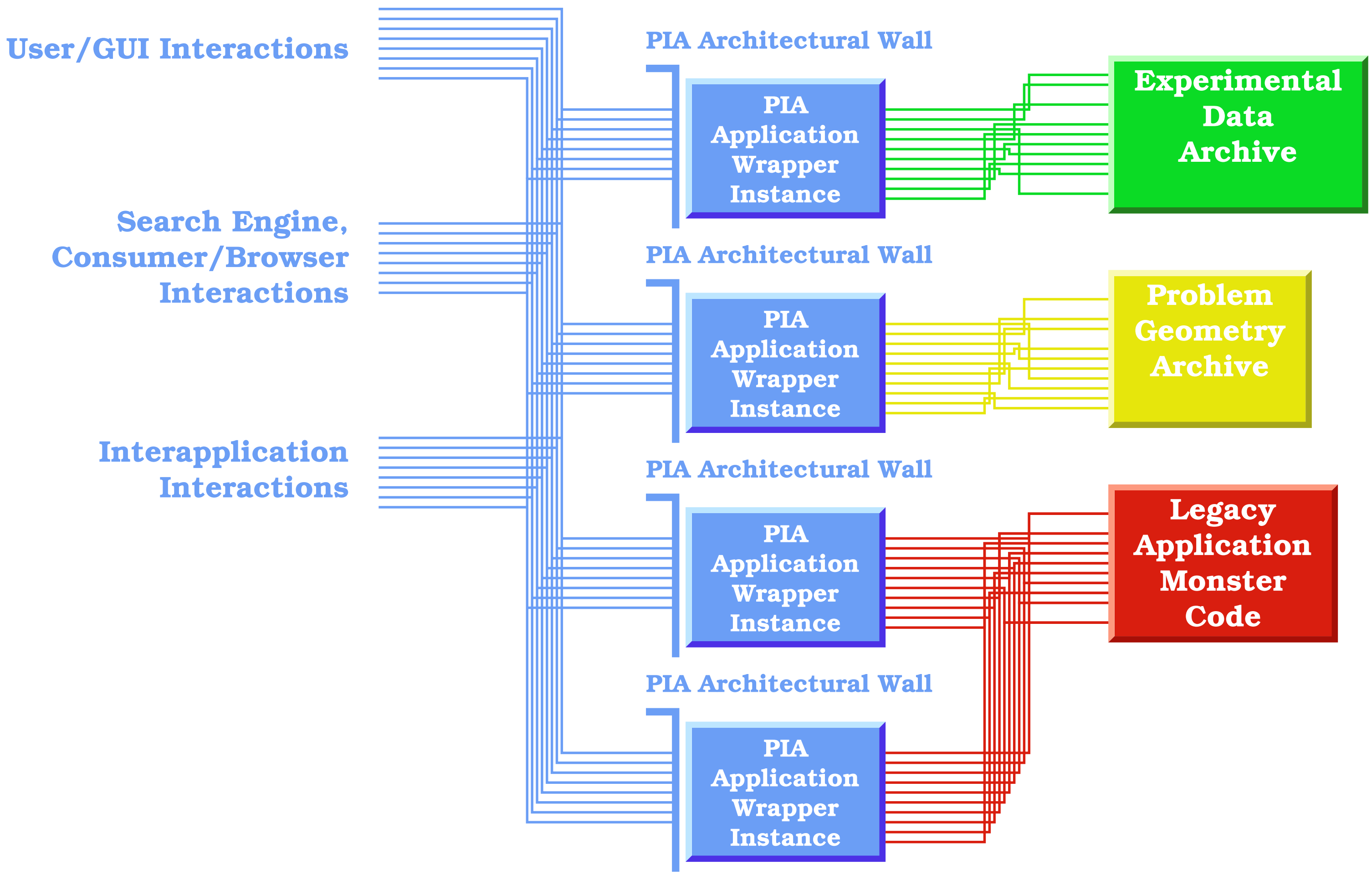
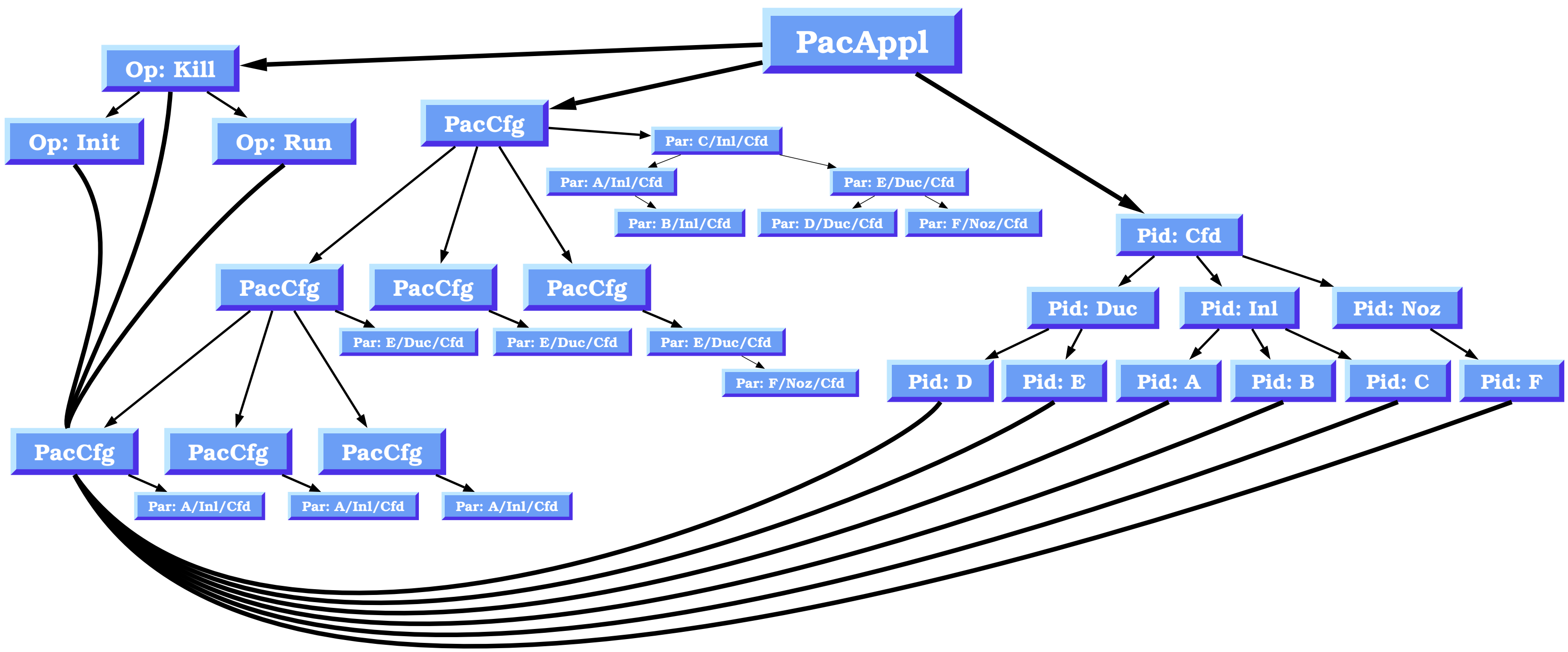


PIA Application Architectural Wall Concept



The PIA Self-Revealing Application Architecture

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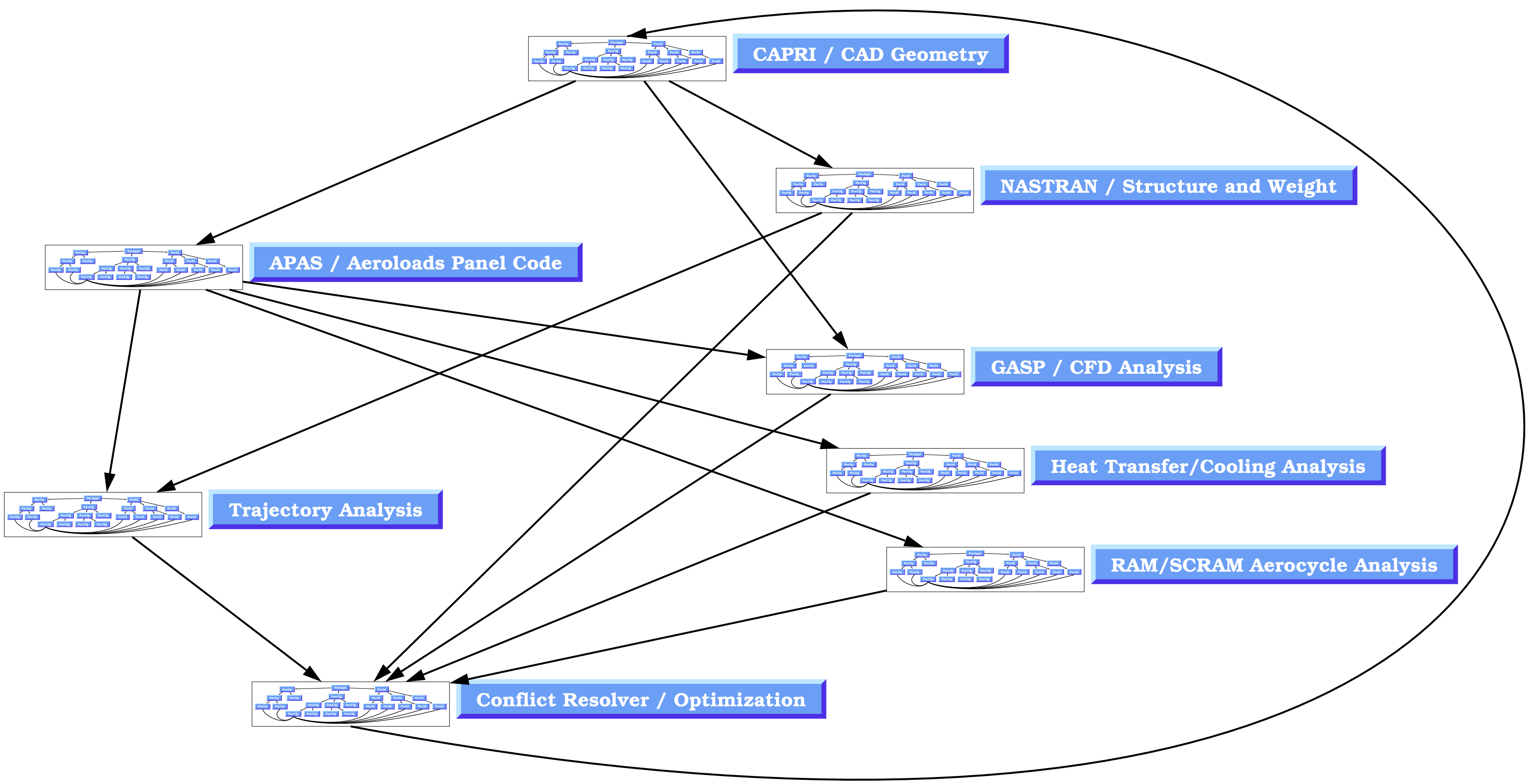

Integrated Application Graphs

Automated Solution Systems

Given a sufficently rich environment, PIA provides the basis upon which application graphs may be automatically assembled.

1. The application object can reveal the set of parameters which it produces and, upon further interrogation, the input parameters needed to generate any particular output.

2. Given a desired output, an automated process similar to a program linker can identify the application producing that parameter. The needed inputs are noted and a recursive search performed to satisfy those needs until only inputs that can be guessed at random remain.

3. The graph is completed with a final loop-back application that guesses initial inputs, runs the analysis, examines the resulting output, and trys new inputs based upon the result.

4. The graph assembly process can be made more efficient by constructing catalogs mapping produced parameters to specific applications.

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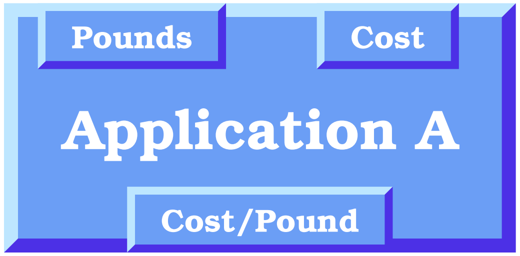

Needed list:
- **Pounds**
- **Cost**

An Automatically-Identified Application Producing a Desired Result

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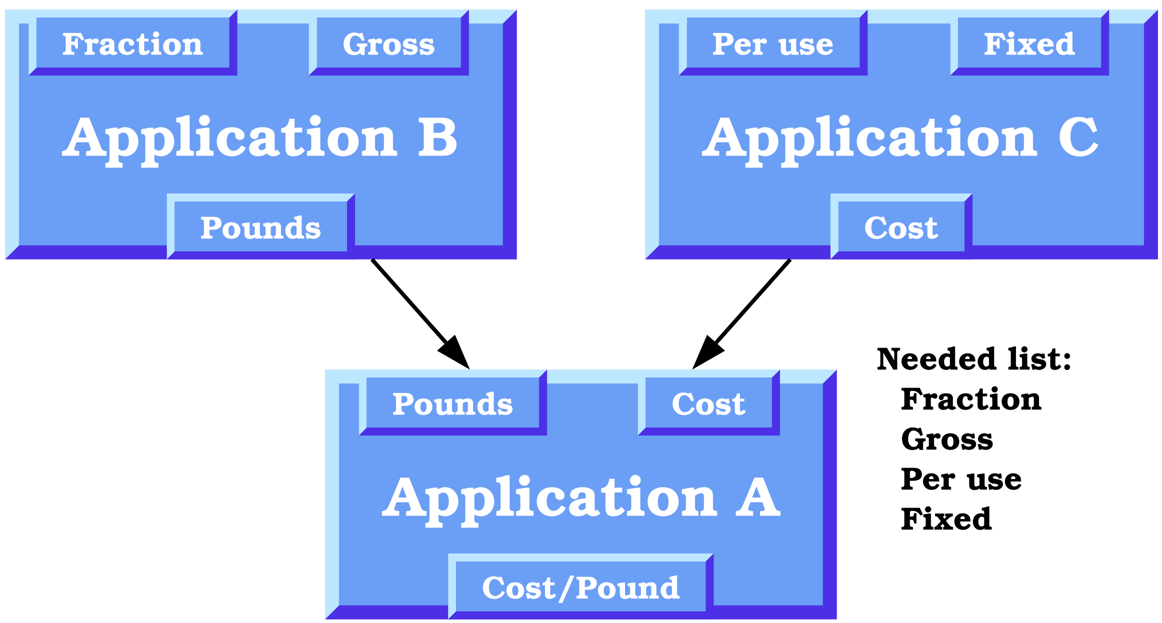

Automatically-Identified Applications Producing Needed Inputs

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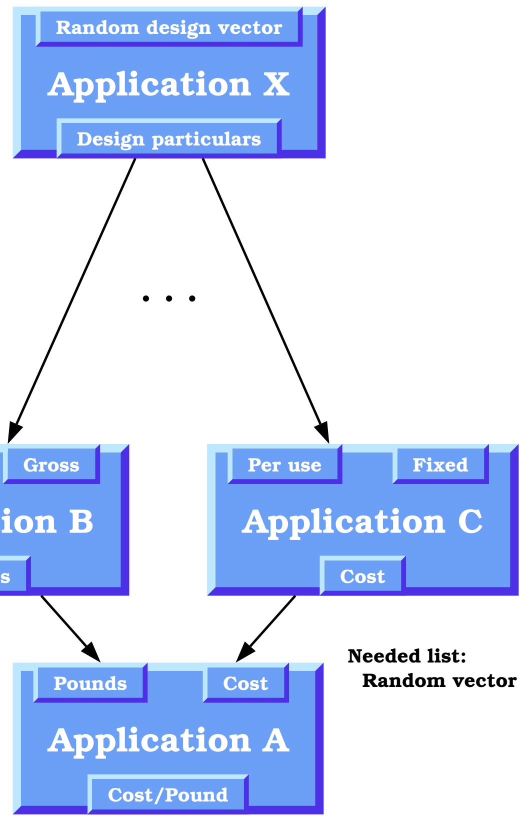

Reduction to Applications Requiring Only Random Inputs

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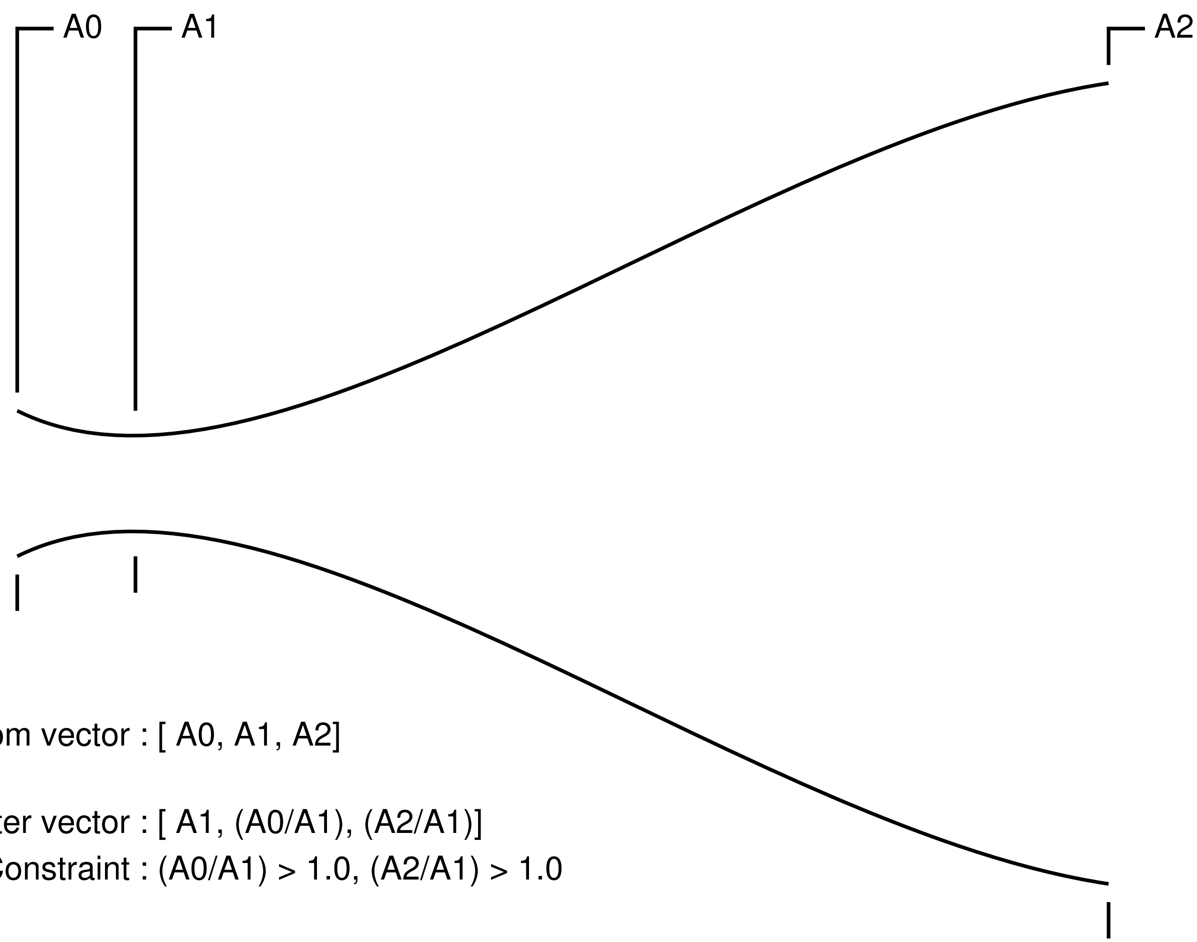

Random vector : [A0, A1, A2]

Better vector : [A1, (A0/A1), (A2/A1)]
Constraint : (A0/A1) > 1.0, (A2/A1) > 1.0

A Rocket Motor Design Application with Random Inputs

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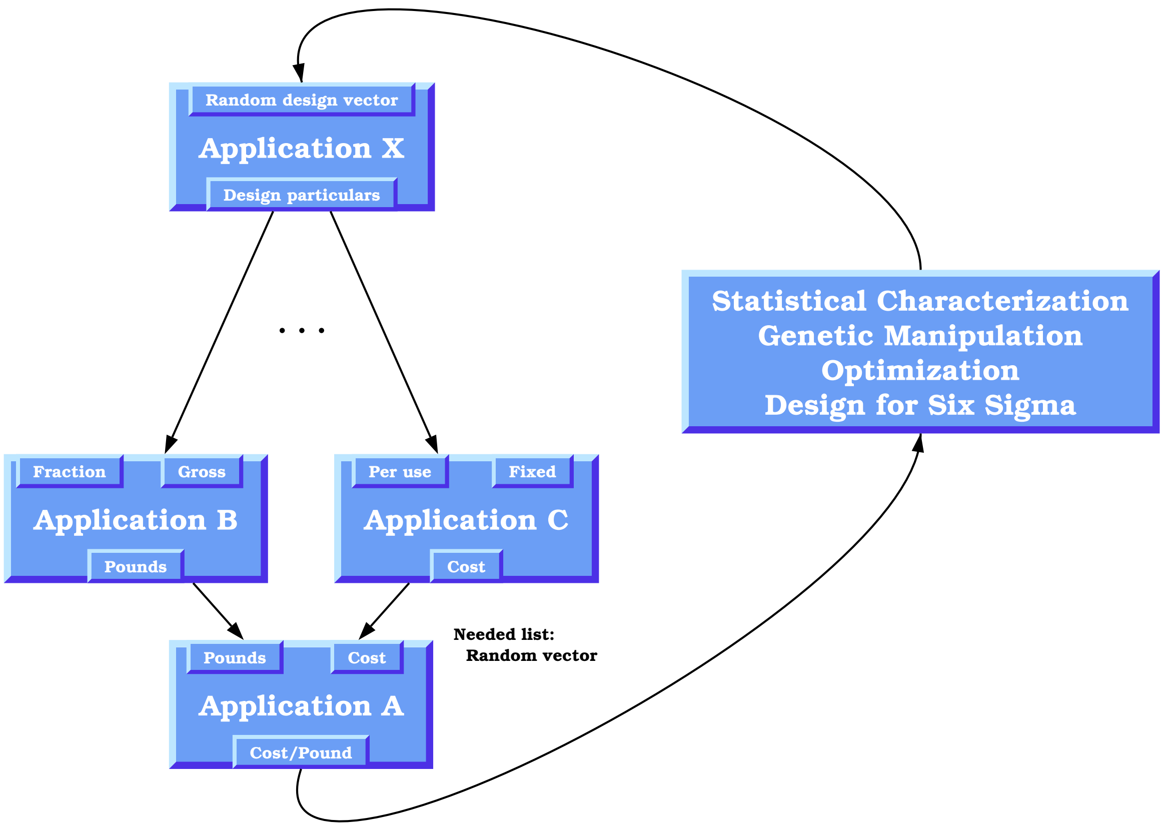

Application of Solution Initialization and Improvement Technology

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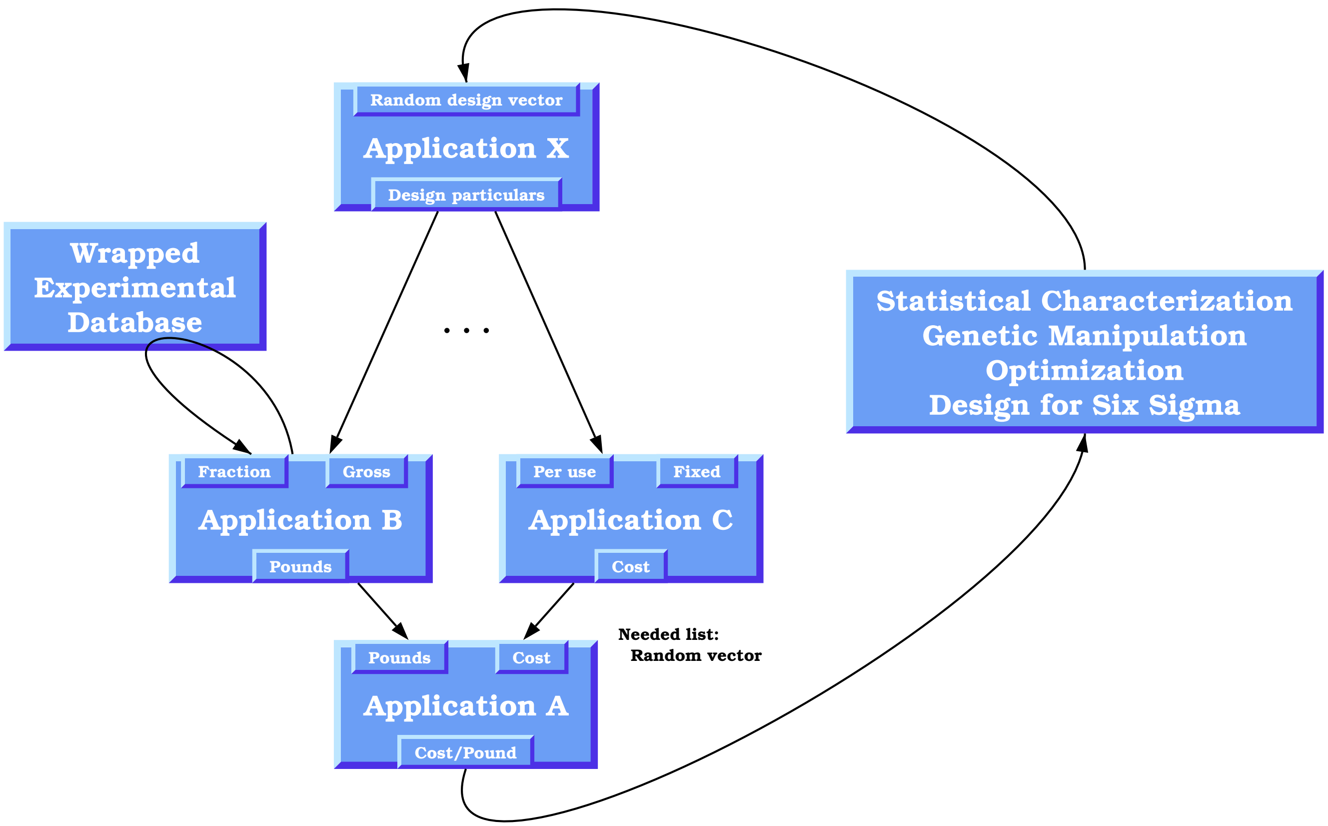

Use of Relevant Experimental (or Other) Information

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Automatic Solution System Benefits

1. Extension of application integration beyond the limits of human capability.
   1.1 With a 99.99% connection accuracy, an integration with 20,000 connections has an 86% chance of having one wrong connection.

2. Elimination of human failings from the solution formulation process.
   2.1 Accurate transfers of information.
   2.2 Dispassionate consideration of alternative strategies; one NASA, one collective.

3. Automated risk assessment of the solution process.
   3.1 Identification of weak or missing technology areas.

4. Discipline expert's team participation time reduced; time freed for discipline development.

Project Status

1. Single-machine, C++ prototype demonstration of technology complete.

   1.1 Propagation of geometry information from ProEngineer to LAPIN through PIA technology demonstrated. Performance improvement from weeks to about an hour.

2. Migration of the architecture to Common Object Request Broker Architecture (CORBA) implementation in progress.

   2.1 Foundation layer classes complete and operational; Application foundation/infrastructure implemented and demonstrated; Full generic application set expected fall/winter CY03.

3. Commercialization planning begun.

   3.1 Three Software Use Agreements in place: Emergent Technologies (LIFT), Tal-Cut Company, Entara Technologies Group.

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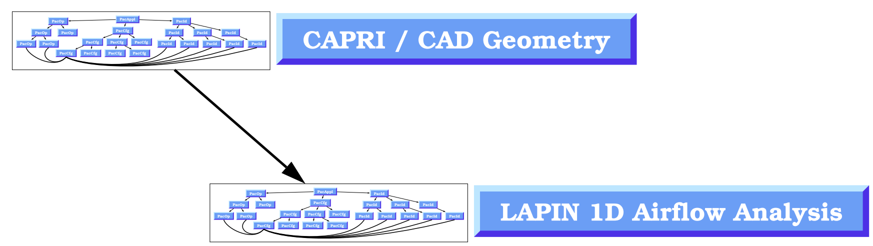
Single-Machine, C++ Prototype Status

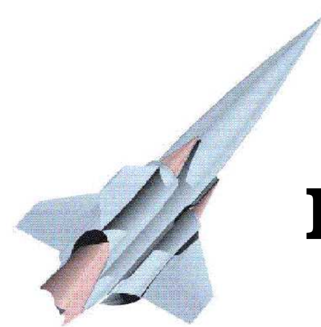
A demonstration of self-revelation, semantic infusion through class derivation, and automated information propagation by kind has been achieved in a single-machine, C++ prototype environment. A speed-up from several weeks to about an hour has been demonstrated.

1. A PIA wrapper to the PTC/ProEngineer CAD environment using the Computational Analysis Programming Interface (CAPRI, MIT/Haimes) technology has been developed.

2. A PIA wrapper for the Large Perturbation Inlet Analysis (LAPIN) CFD code has been developed.

3. The two application wrappers have been formed into an application graph and automatic propagation of the GRC RBCC geometry information from the CAD environment to the CFD code has been demonstrated.





RBCC

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CORBA Migration Benefits

1. Allows the architecture to extend into a collective of trusted servers and server clusters.
2. Allows the extension of data spaces to terabytes, petabytes, exabytes, and beyond.
3. Allows multiple simultaneous consumers of served information.
4. Allows cross-language consumer capabilities; a Java GUI may be made to access a C++ server.
5. Allows the services of an application to be provided without the necessity of releasing the proprietary, capital-asset code to those receiving those services; software maintenance reduction.

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Tentative Commercialization Plan -- Core Technology

Core integration technologies to be released as open-source freeware available for download from a publically-accessible code versioning server.

1. Avoids the proprietary trap in which company assets are locked up in the vendor's confidential data format and are accessbile only through the vendor's tools.
2. Provides an expansive test/debug/redesign/augmentation community at near-zero cost to NASA.
3. Allows low-cost, boot-leg experimentation before buy-in.

    3.1 Geeks can download it, try it, see how it works, and then make their case to management, rather than

    3.2 Make their case to management, spend a bundle, get it, try it, find out it doesn't do what they thought, apologize to management, and lose their jobs.

4. Substitutes cross-corporation/agency cooperation on a shared standard for big-corporation/agency mandates for specific vendor solutions. Especially avoids the problem when two "big boys" don't agree.

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Tentative Commercialization Plan -- Revenue Streams

1. Knowledge delivery.
   - 1.1 Consulting, training.
   - 1.2 Service delivery, in the manner of Redhat, Inc.
2. Ancillary software products.
   - 2.1 Application wrapper's workbench.
   - 2.2 Discipline-specific visualizers/workbenchs.
   - 2.3 Operational suites; statistical characterization, design of experiments, optimization, six-sigma, in the manner of Engineous Software Inc., ISight.
3. Plug-and-play application products; for those who want to be private.
4. Served application collectives; direct sales of application services without shipping code to the customer.
5. Raw hardware sales; big server farms.

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Tentative Commercialization Plan -- Standards Organizations

Core integration technologies and semantic libraries will eventually need to transfer to a standards organization.

1. Transfer to a standards body should not be (and probably won't be) immediate; many initial adjustments may be needed once this hits the fan and the standards process slows this sort of thing to a crawl.

2. The principal standards focus will probably be on discipline-specific parameter libraries; for PIA to succeed, each encapsulated number must be exactingly defined. As much as possible will be taken from existing efforts; CFD General Notation System (CGNS) and the like.

3. Some disciplines of interest to NASA are entering very interesting times and will require considerable standards efforts. For example, hypersonic flows transcend traditional computational fluid dynamics concepts as extreme temperatures change the chemistry of the fluid.

4. Another standards effort will be needed for application validation and accreditation.

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Tentative Commercialization Plan -- Unresolved Issues

1. The CORBA-served PIA application layer uses strong Rivest/Shamir/Adleman (RSA) encryption to protect password and other sensitive information exchange and storage. Additionally, omniORB V4.x foundation supports OpenSSL communications protection.

2. Export law appears to forbid the release of strong encrytpion technology.

3. Believable protection of such information is vital for commercial acceptance and success; users and providers will not hazard their valuable or sensitive resources unless a standard of protection is met. Exportable weak encryption simply does not rise to this level.

4. The RSA algorithm is well known, well understood, well implemented, and well distributed on a world-wide basis; export control provides nothing beyond the mere appearance of propriety.

5. Competent legal guidance is needed. Adjustment of export controls to reflect existing realities would be good, but is probably unlikely.

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Tentative Commercialization Plan -- Project Needs

PIA technologies might truly change the way we do business; however, the project needs someone at the top of something big (SLI, 3rd Gen) to notice and say "I want that!".

1. Individual researchers seldom see much need for integration technology; they obtain their data, present their charts, and are happy.

2. Project managers usually range from understanding to adamantine about integration technology needs; however,

   2.1 Their mandate is to deliver a specific product,

   2.2 Their funding does not include cross-cutting tool developement, and

   2.3 They have little lattitude to wander off target.

3. Only people at or near the top have the momentum necessary to move an agency-wide agenda; however, these people seldom have the time to notice technologies such as PIA.

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Project Integration Architecture Summary

1. PIA has significant potential for radically altering the way we do business.

2. Key technology components have been demonstrated in a prototype form.

3. Migration of the technology to a net-distributed form is well underway. A core-technology implementation should be available during CY03.

4. The comprehensive and exhaustive analysis of entire complex systems (launch systems, advance air transport vehicles) is enabled.

5. Such analysis can be assembled by automatic means.

6. Planning for commercialization has begun.

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Backup Slides

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Basic Object Primer

1. Objects are defined in classes, but are worked with as individual instances of their class.

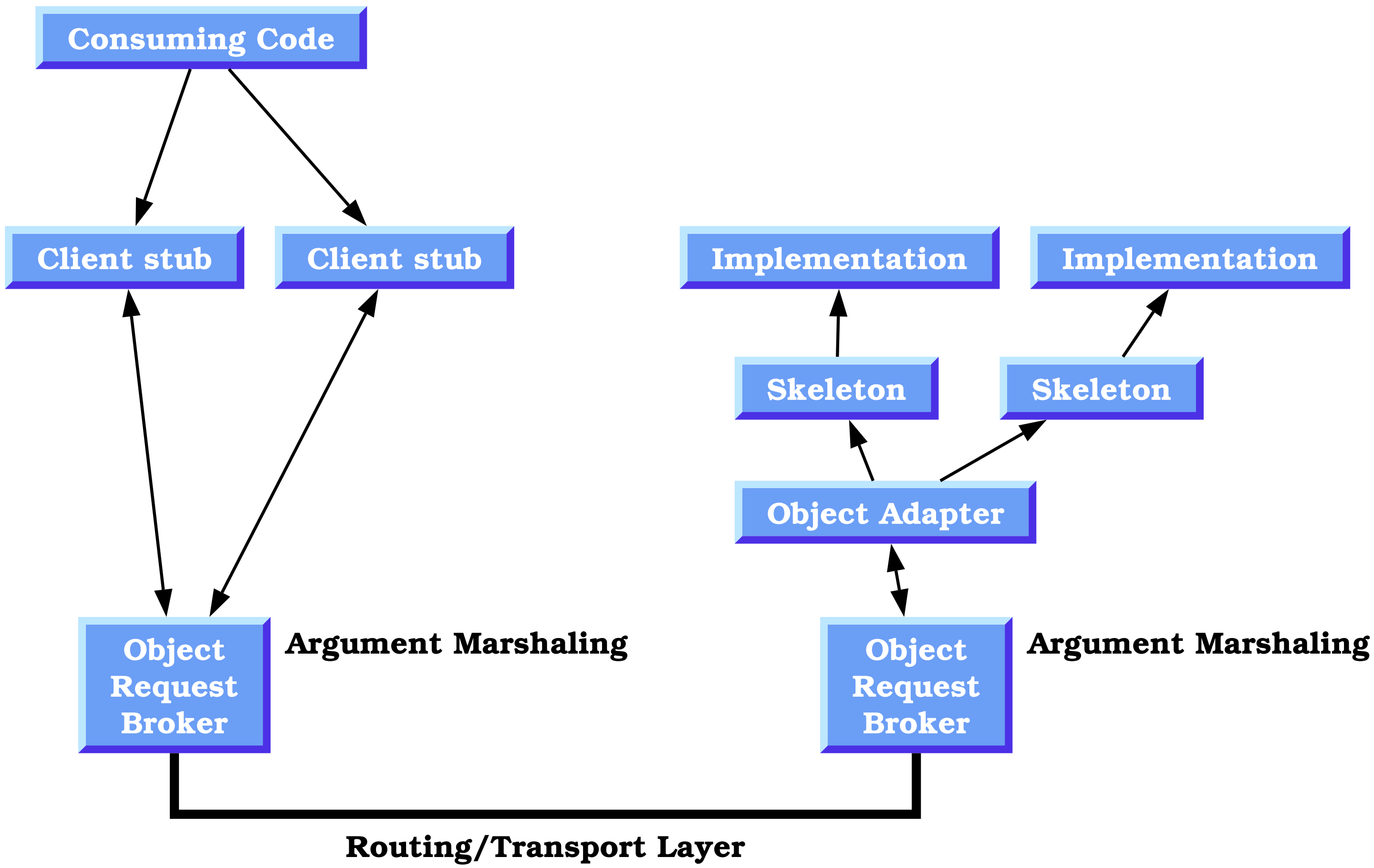
2. Objects usually have functionality and data. Data may be shared among all the instances of a class or may be individual to each instance. Functionality is shared by all instances.

3. Classes may be derived from classes, inheriting the attributes of the parent class.

4. Derived classes may add to, override, alter, extend, turn off, or otherwise mangle inherited functionality.

5. The correct functionality is obtained without regard to whether or not the program "knew" the exact kind of object in use.

6. Usually, the first thing provided is a way to find out the kind of any given object.



CORBA at a Glance