



NewToolsNeeded 06/26/17



*Not everyone
needs the same tools!*

*Which are you using?
&
What do you need?*





***A Disruptive Solution to building
Extremely Complex
Models,
Simulations,
& Software
On Parallel Processors***



Disruptive Solution To Parallel Processing



MEASURABLE GOALS:

- **Provide an order of magnitude reduction in the time & cost to develop models, simulations & software;**
- **Provide 4 to 6 orders of magnitude improvement in simulation/software run-time speed;**
- **Allow application experts to design, build, and test models and simulations directly;**
- **Allow newcomers to a project to quickly learn and understand complex models.**



Disruptive Solution To Parallel Processing



REPRESENTATIVE APPLICATIONS:

- Adaptive Control of Large Groups of Autonomous Moving Platforms
- Human Body Organ simulation
- Human Brain – Artificial Intelligence modeling
- Global Climate prediction
- Currency Market prediction
- Chemical - Molecular structure simulation
- Scanning, sorting, and correlating massive databases (Big Data)
- Weather prediction in mountainous terrain
- Power distribution simulation
- Electro-magnetic wave simulation
- Global HF power transmission
- Global Military Planning - Multiple moving platform simulation

PSI has worked most of these applications

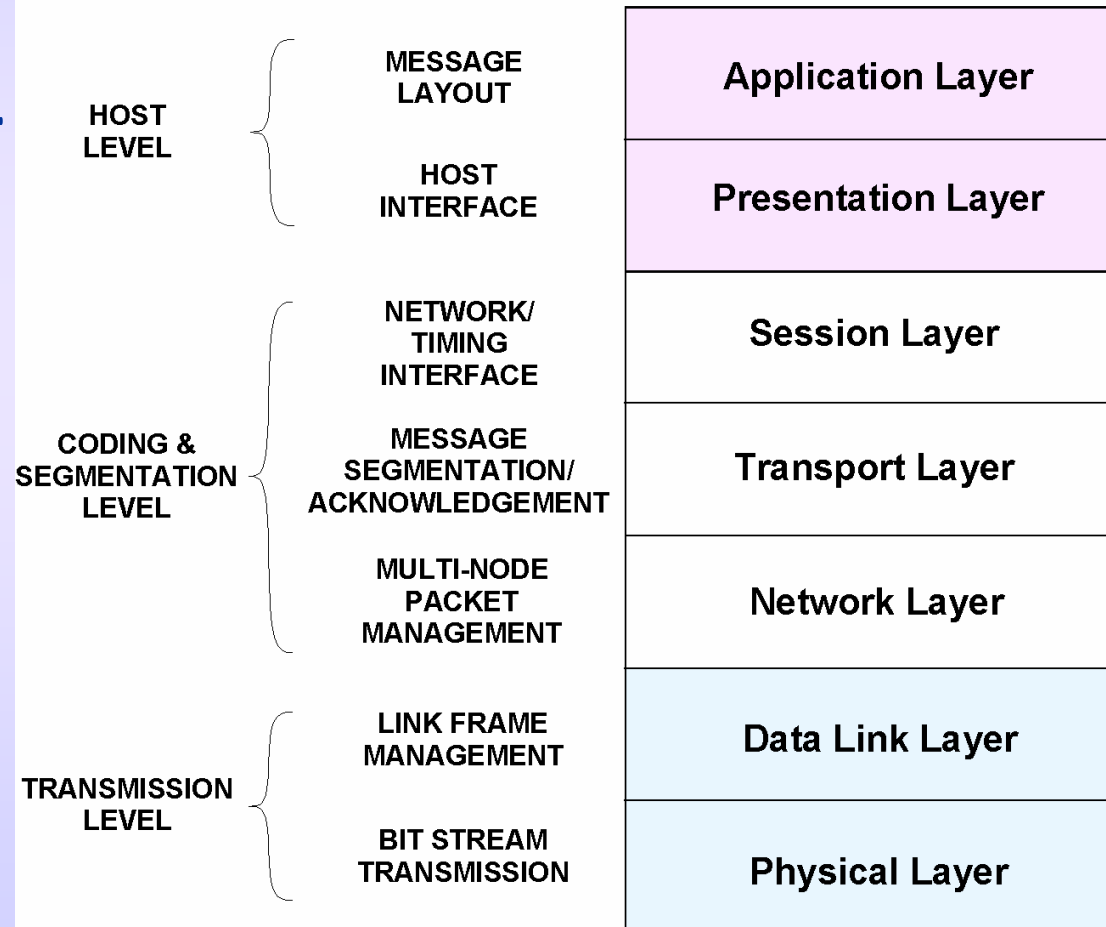


Disruptive Solution To Data Comm



**THIS MODEL
EXPOSED
THE PRIOR
PROBLEM
AREA ==>**

Open Systems Interconnection (OSI) - Seven Layer Model for Communication Technology



SEVEN_LAYER_MODEL 03/21/18

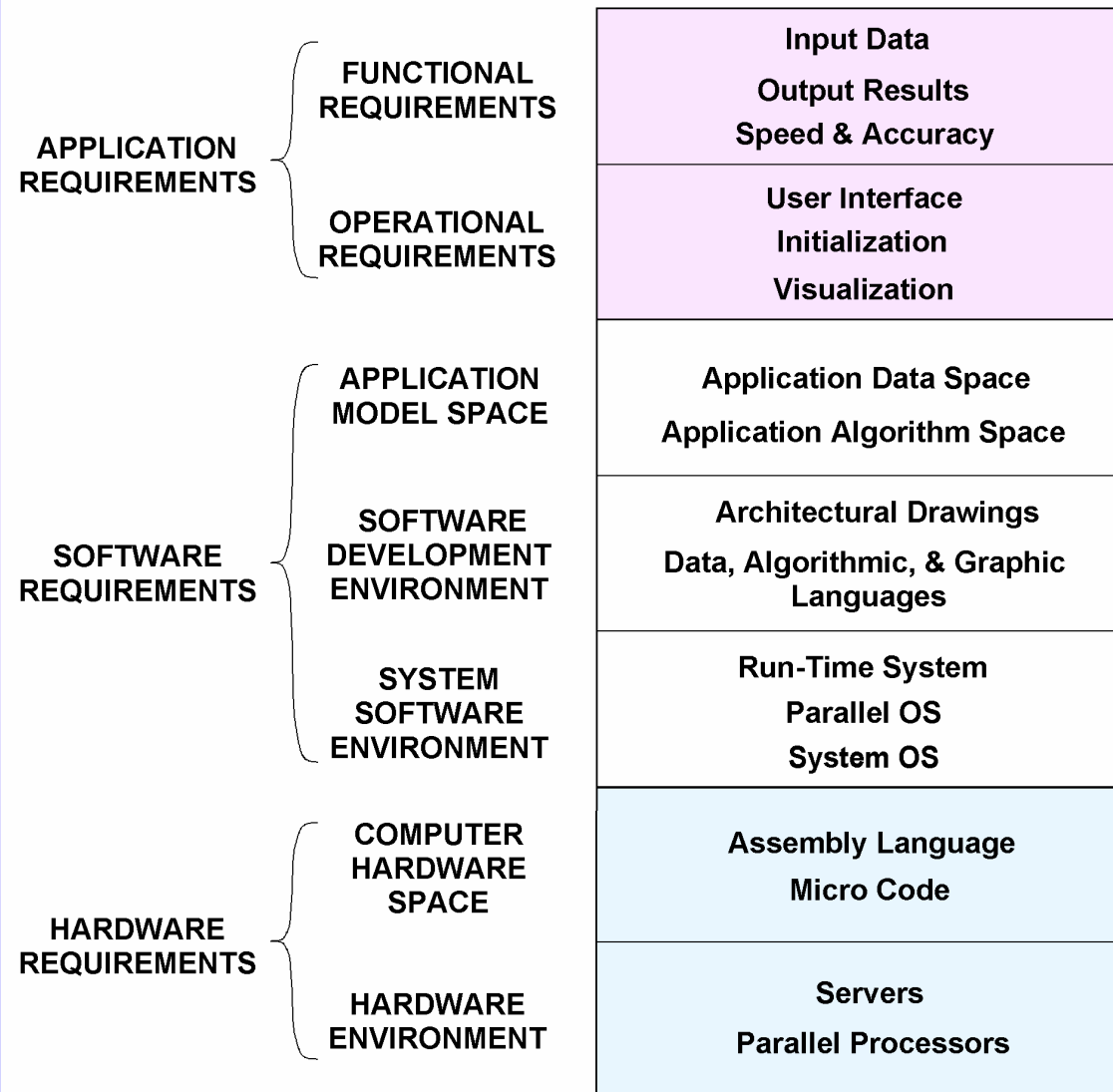


Disruptive Solution To Parallel Processing



Seven Layer Model for Computer Technology

**THIS MODEL
SHOWS THAT
SOFTWARE ==>
IS THE
PROBLEM!**

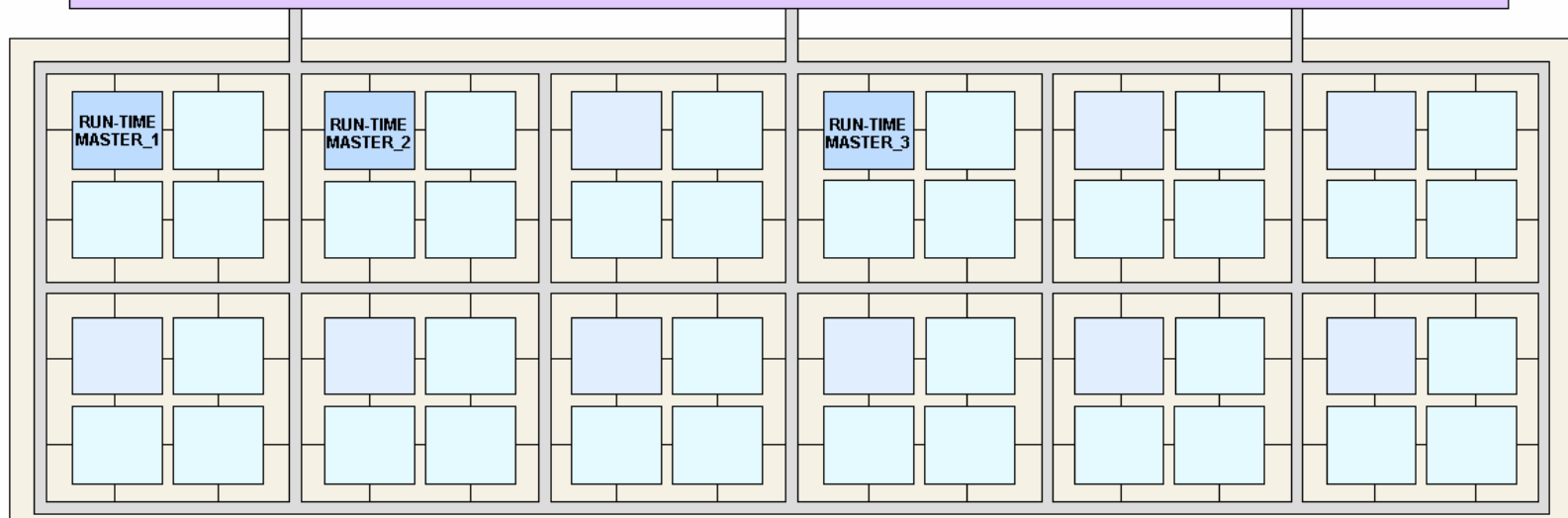
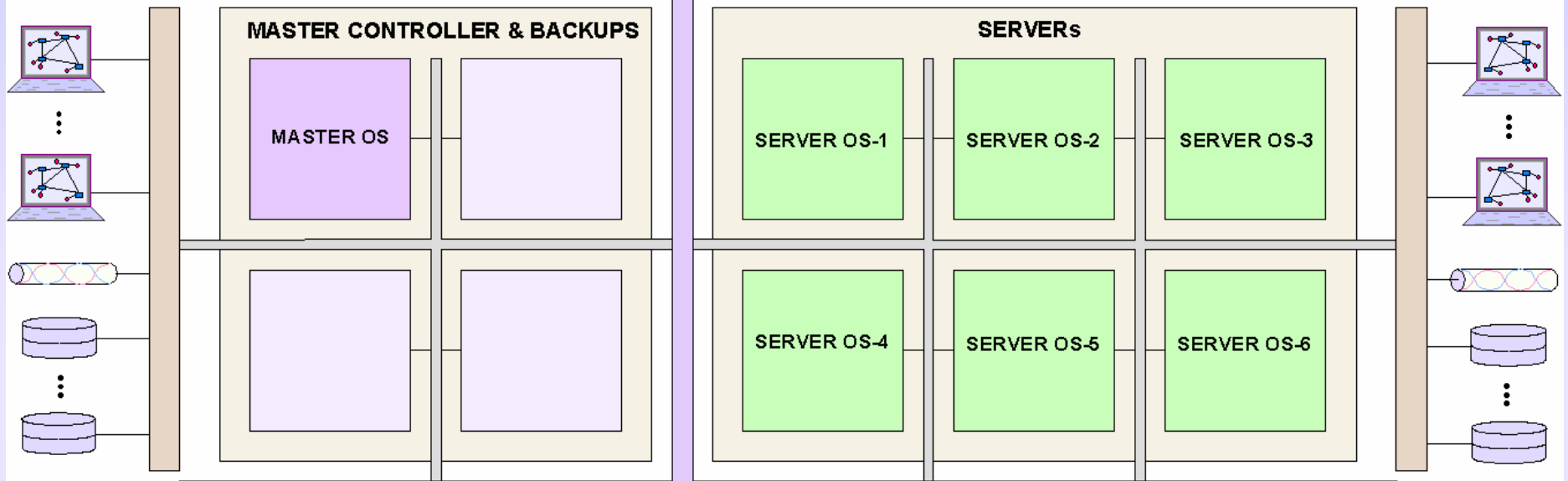




Servers Are Not Parallel Processors A Multi-Tasking OS is Not a Parallel OS



SERVER ARCHITECTURE



PARALLEL PROCESSOR ARCHITECTURE



Disruptive Solution To Parallel Processing



SOFTWARE IS AN EXTENSION OF MATHEMATICS:

- **Must pick the “Best Spaces” to represent the problem;**
- **The Best Spaces simplify the algorithms;**
- **Simple algorithms run much faster;**
- **Simple algorithms are much easier to understand;**
- **Newcomers to a project quickly learn the software**

Also, What is a “Software Module” ?

And, What is “Software Architecture” ?

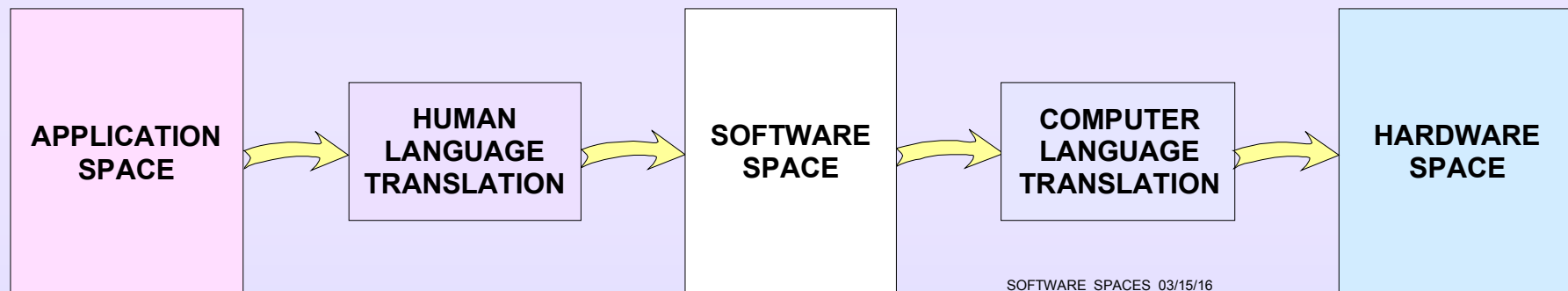
These terms are used throughout the literature – *undefined!*



Disruptive Solution To Parallel Processing



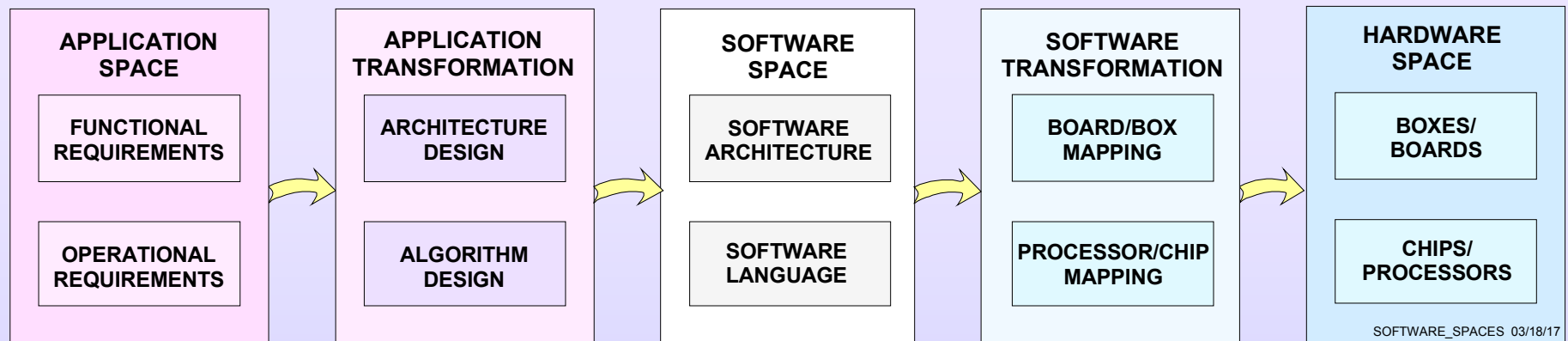
Spaces for Translation of Application Requirements into Software & Then into Hardware



Cannot solve the problem without defining the spaces first!



Spaces for Translation of Application Requirements into Software & Then into Hardware





Disruptive Solution To Parallel Processing



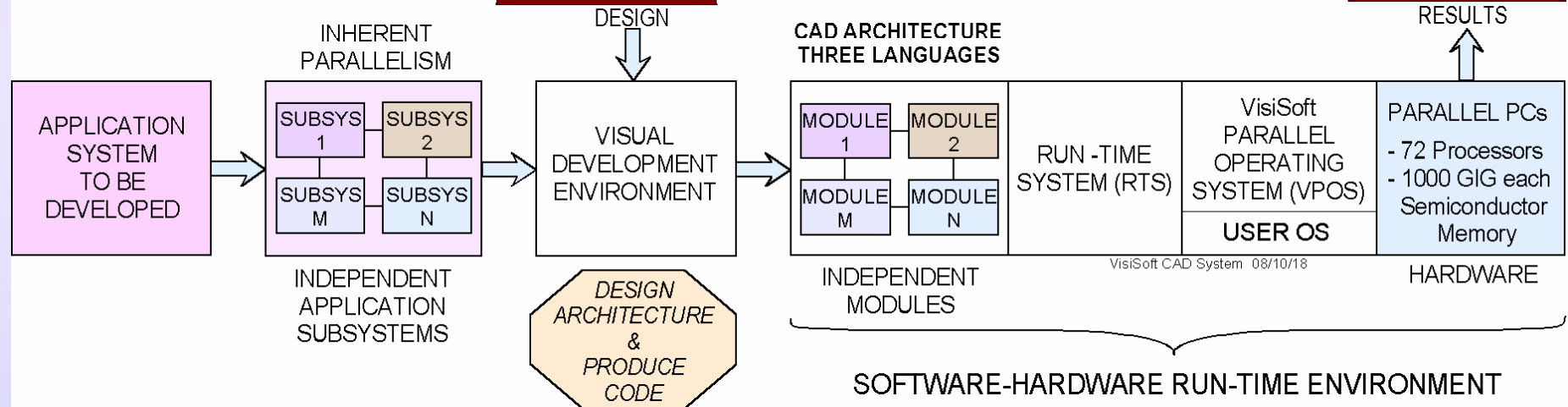
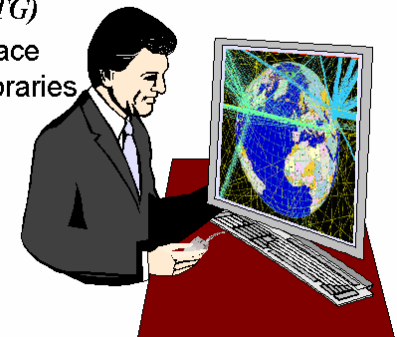
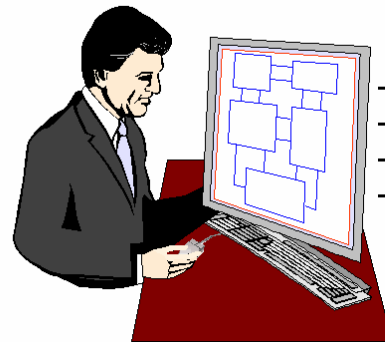
APPLICATION EXPERTS USE

Visual Software Environment (VSE)

- CAD GUI
- Engineering Drawings
- Natural Language
- Large Libraries

Run Time Graphics (RTG)

- Graphical User Interface
- Large Geographic Libraries
- Interactive Facilities



Visual Software Engineering Using A CAD System For Building Complex Software



Disruptive Solution To Parallel Processing



a RESOURCE
 -
 Contains
 Hierarchical
 Data Structures
 To
 Easily Map
 Complex Spaces

RESOURCE: TRANSCEIVER		INSTANCES: TRANSMITTER RECEIVER	
GENERAL PARAMETERS			
1	TRANSMITTER_POWER	REAL	INITIAL_VALUE 100
1	RECEIVER_THRESHOLD	REAL	INITIAL_VALUE 120
RADIO			
1	TRANSCEIVER	STATUS	TRANSMITTING RECEIVING IDLE OFF
1	LOCATION		
2	X_POSITION	REAL	
2	Y_POSITION	REAL	
2	ELEVATION	REAL	
1	ANTENNA_HEIGHT	REAL	
1	ANTENNA_GAIN	REAL	
RECEIVER_CONNECTIVITY_VECTOR			
1	POWER_AT_RECEIVER	REAL	
1	TOTAL_NOISE_POWER	REAL	
1	CONNECTIVITY_MATRIX		
2	PROPAGATION_LOSSES		
3	TERRAIN_LOSS	REAL	
3	FOLIAGE_LOSS	REAL	
3	TOTAL_LOSS	REAL	
2	SIGNAL_POWER	REAL	
2	SIGNAL_TO_NOISE_RATIO	REAL	
2	LINK_DELAY	REAL	
2	LINK	STATUS	GOOD FAIR POOR
TRANSCEIVER_RULES			
1	TRANSCEIVER_PROCESS	RULES	GOOD_RECEPTION CONFLICTING_RECEPTION CONFLICTING_BROADCAST

A Space / Data Structure



Disruptive Solution To Parallel Processing



a PROCESS
-
Contains
Hierarchical
Rule Structures
That Support
One-in One-out
Independent
Control Structures

```
PROCESS: RECEPTION                                RESOURCES: TRANSCIEVER
INSTANCES: TRANSMITTER                            MESSAGE_FORMATS
           RECEIVER                                TRANSMITTER_OUTPUT

START_RECEPTION
  IF TRANSCIEVER IS IDLE
    EXECUTE GOOD_RECEPTION
  ELSE IF TRANSCIEVER IS RECEIVING
    EXECUTE CONFLICTING_RECEPTION
  ELSE IF TRANSCIEVER IS TRANSMITTING
    EXECUTE CONFLICTING_BROADCAST .

GOOD_RECEPTION
  IF SIGNAL_TO_NOISE_RATIO IS GREATER_THAN RECEIVER_THRESHOLD
    SET TRANSCIEVER TO RECEIVING
    ADD SIGNAL_POWER TO TOTAL_POWER_AT_RECEIVER .
    CALL DECODE_MESSAGE .

  IF MESSAGE_TYPE IS FORMAT_A
  AND SYNC_CODE IS VALID
  AND LAST_SYMBOL IS A_TERMINATOR
    EXECUTE SEND_ACKNOWLEDGEMENT .

CONFLICTING_RECEPTION
  IF POWER_AT_RECEIVER IS GREATER_THAN SIGNAL_POWER
    SCHEDULE ABORT_RECEIVE NOW .

CONFLICTING_BROADCAST
  CANCEL_END_RECEIVE NOW
  SCHEDULE START_RECEIVE IN EXPON(0.83) MILLISECONDS
  WITH PRIORITY 80

SEND_ACKNOWLEDGEMENT
  MOVE ACKNOWLEDGEMENT TO TRANSMIT_MESSAGE_BUFFER
  IF DESTINATION IS BROADCAST
    SEARCH LINK_CONNECTIVITY_VECTOR OVER RECEIVER
    EXECUTING_TRANSMISSION
    WHEN LINK IS GOOD
  ELSE EXECUTE_TRANSMISSION .

TRANSMISSION
  SCHEDULE LINK_RECEPTION
  IN LINK_DELAY MICROSECONDS
  USING TRANSMITTER, RECEIVER
```

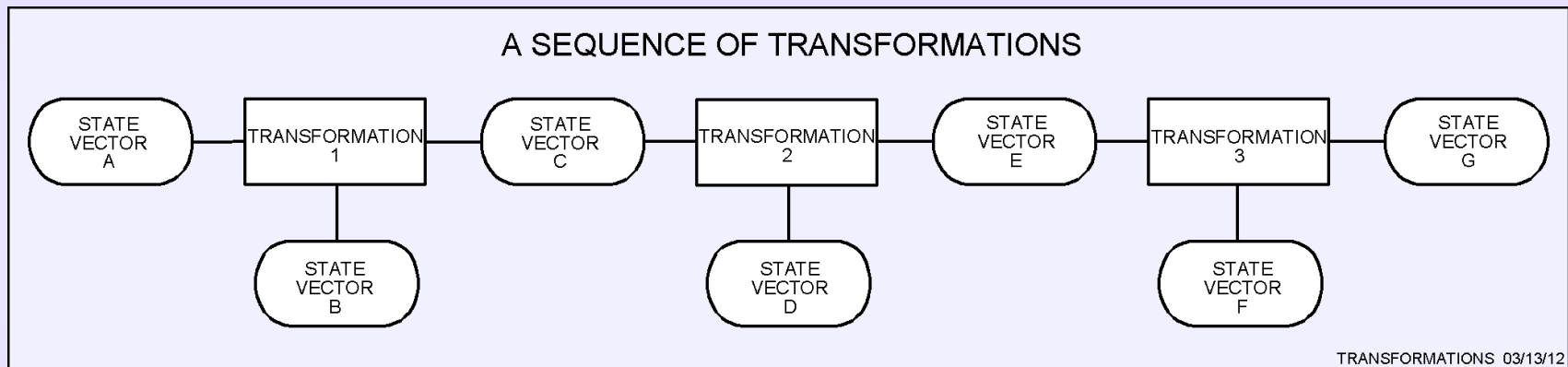
A Transformation / Rule Structure



Disruptive Solution To Parallel Processing



Spaces for Translation of Application Requirements into Software & Hardware



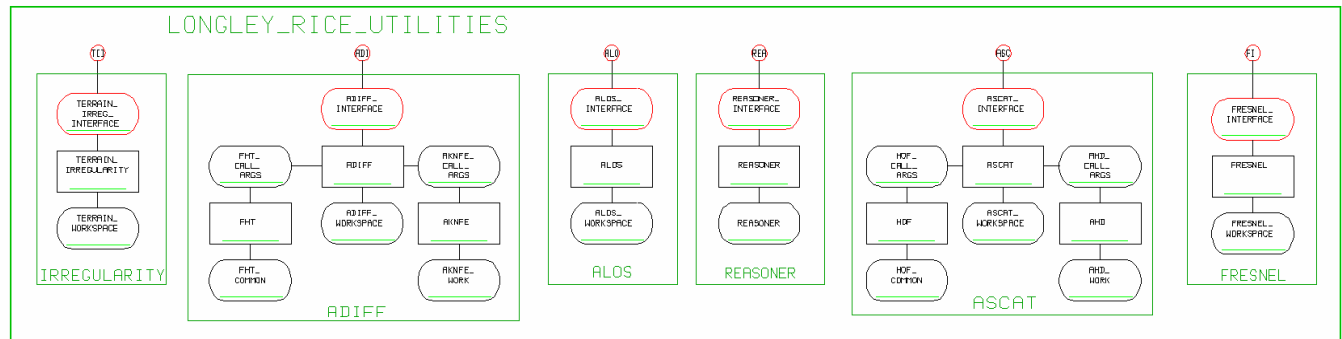
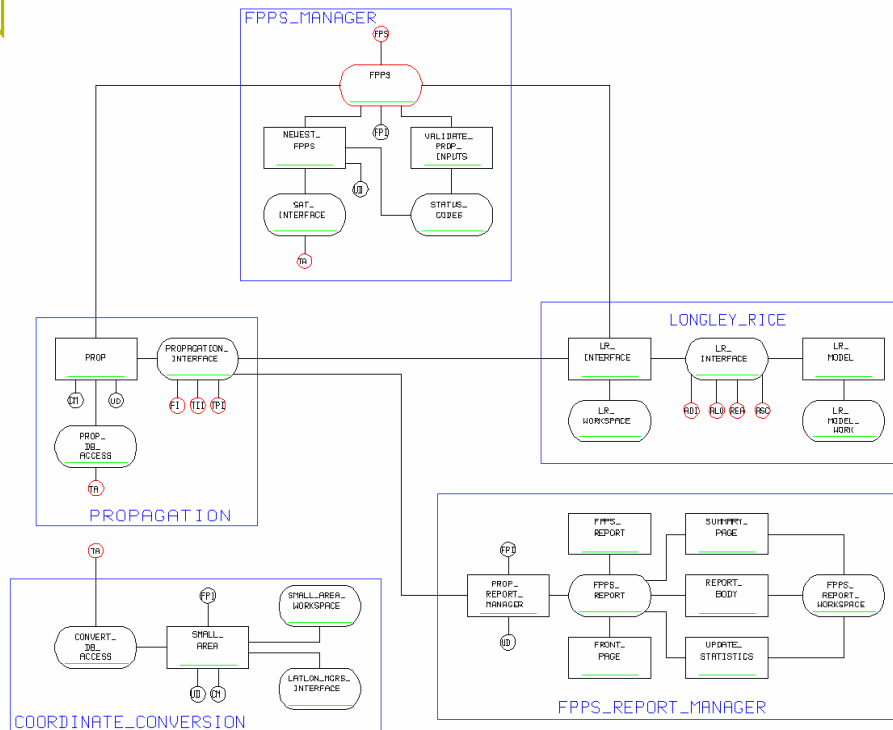
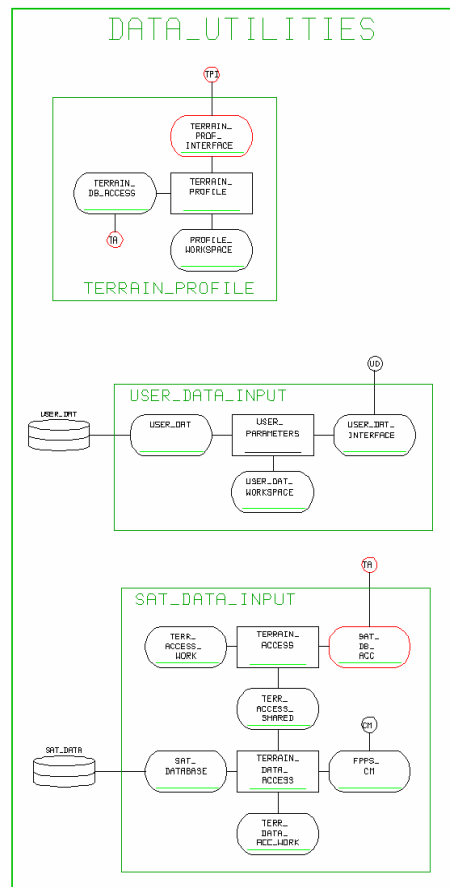
**Connecting Resources & Processes to
Create a Sequence of Transformations
- Mathematically Defining a Module**



Disruptive Solution To Parallel Processing



PROPAGATION_PREDICTION



FPPS 08/26/07

An Architecture - a Hierarchy of Software Modules

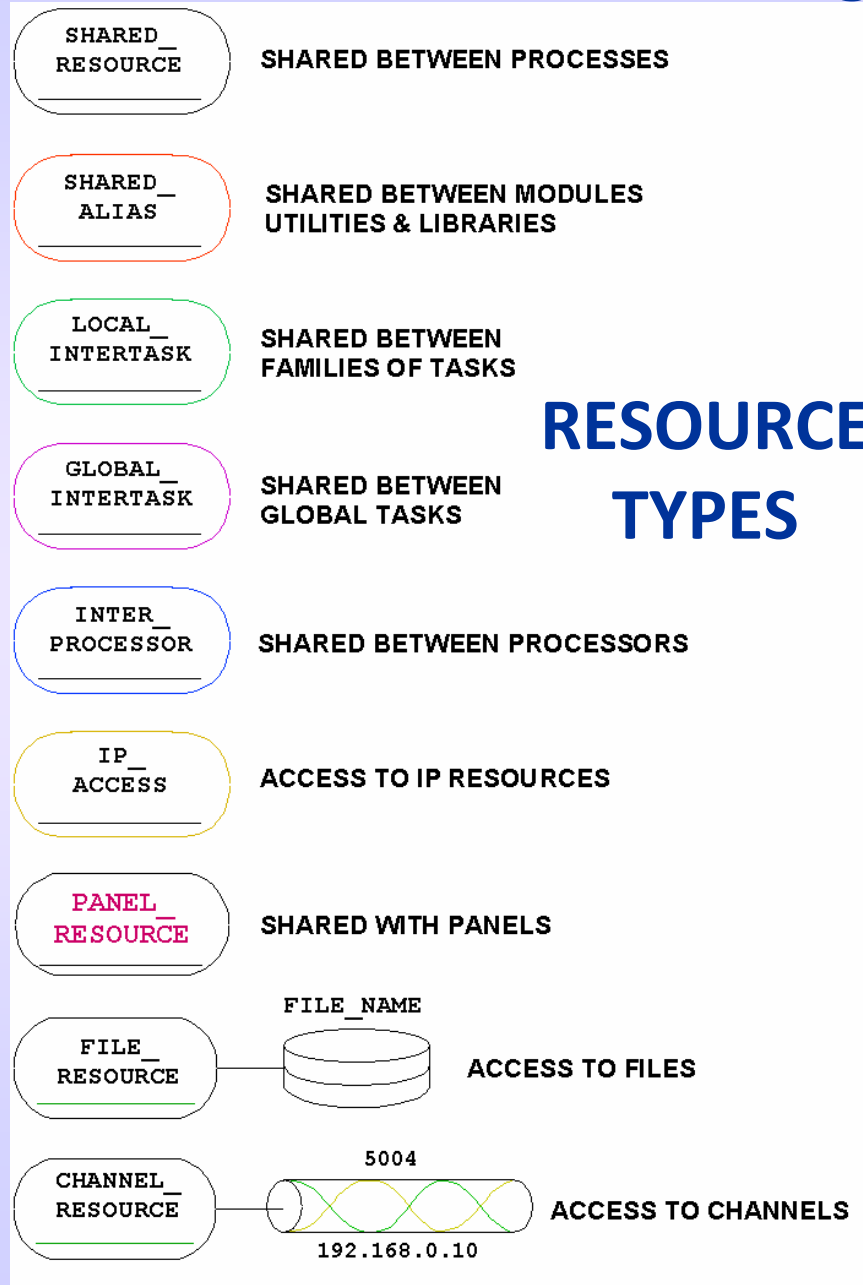


Disruptive Solution To Parallel Processing



**RESOURCE
TYPES ARE
CRITICAL TO
SHARING
DATA &
MAPPING
MODULES
ONTO
PARALLEL
PROCESSORS**

RESOURCE TYPES





A FEW SAMPLE PROCESS (INSTRUCTION) FACILITIES

UNDERSTANDABILITY – Shannon: - Theory of Communications

EXECUTE RULES – Mills: - One-In One-Out Control Structures

SCHEDULE & CANCEL PROCESSES (On Same or Other Processors)

RELEASE & ACCESS MEMORY RESOURCES (On Other Processors)

WAIT FOR EVENTS (On Other Processors)

START & END TASKS (On Other Processors)

SEARCH MULTI-DIMENSIONAL / HIERARCHICAL TABLES

READ & WRITE COMPLEX RECORD / FILE STRUCTURES

SEND & RECEIVE COMMUNICATION PACKETS To/From Servers

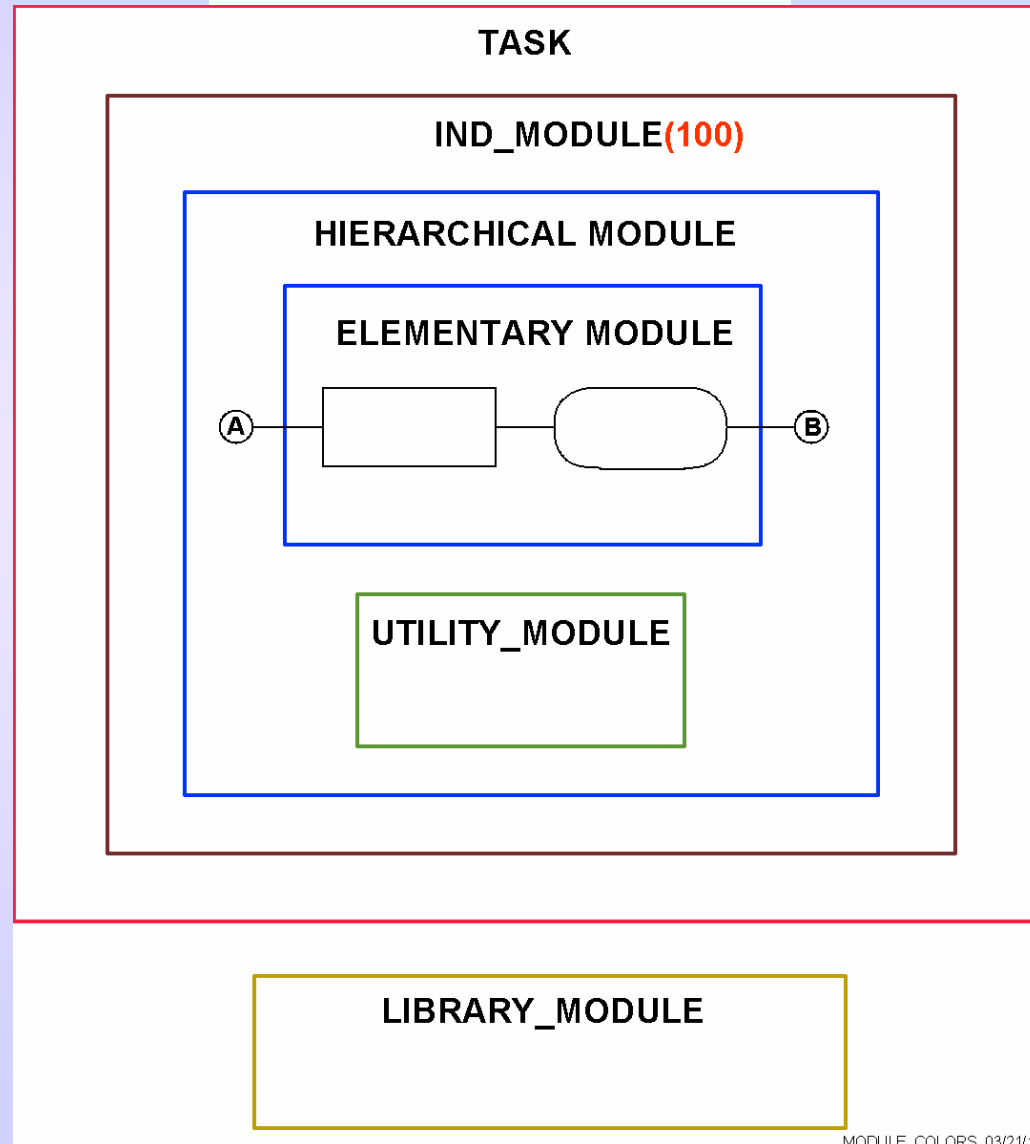


Disruptive Solution To Parallel Processing



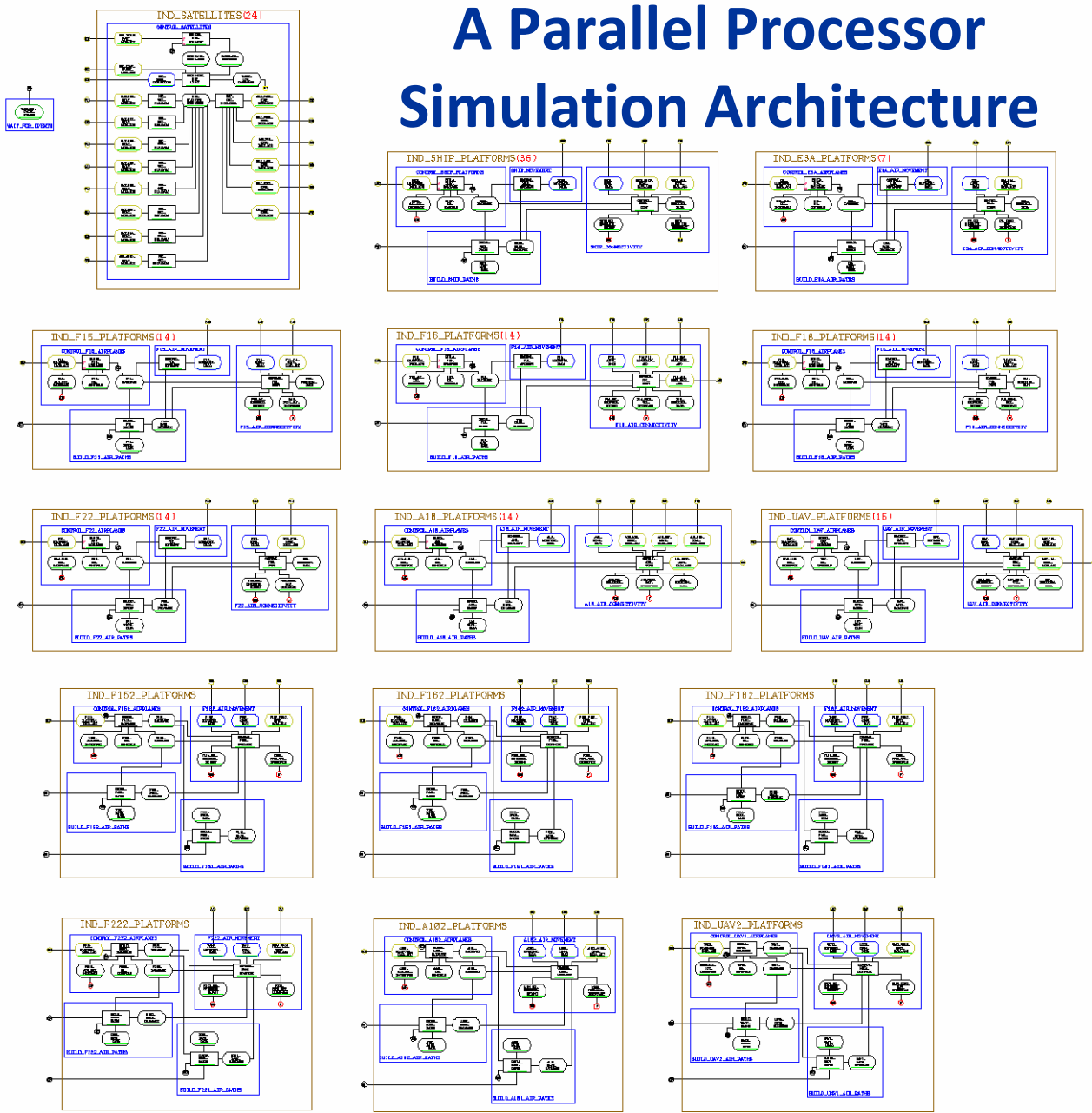
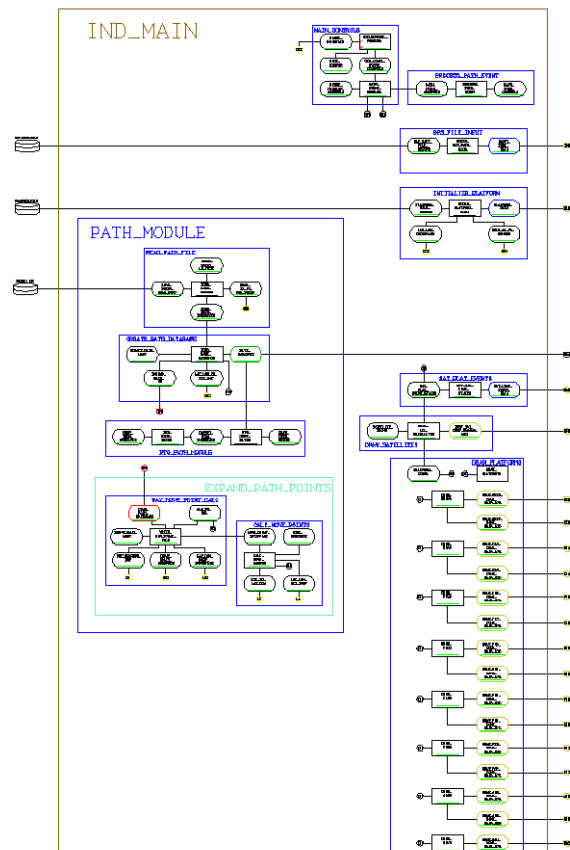
MODULE TYPES

**MODULE
TYPES ARE
CRITICAL TO
INDEPENDENCE
&
ARCHITECTURAL
MAPPING OF
MODULES
ONTO
PARALLEL
PROCESSORS**



A Parallel Processor Simulation Architecture

GLOBAL_PLANNER



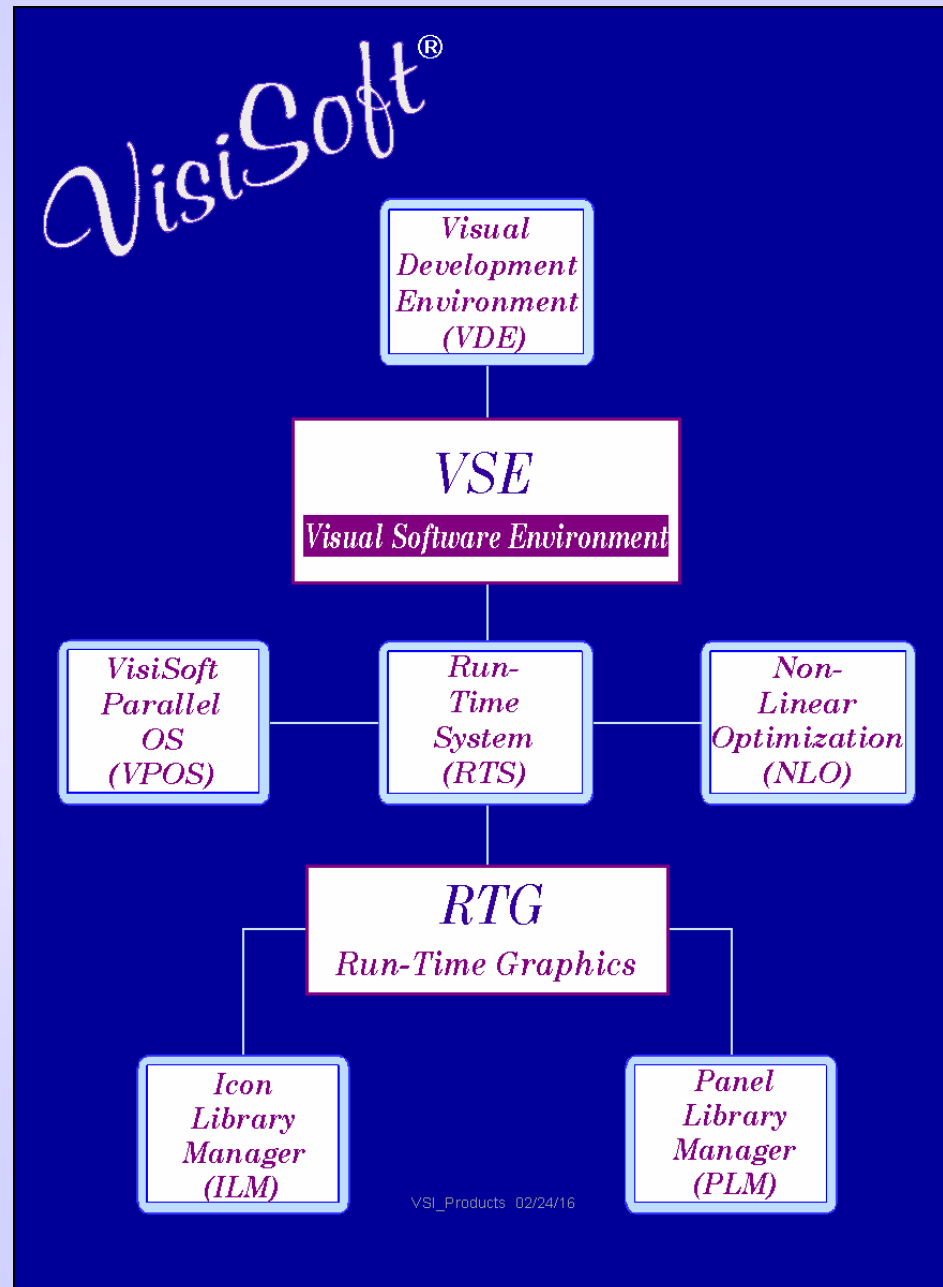
GLOBAL_PLANNER
153 PLATFORMS
16 Processor PC
12 hour scenario
2.31 seconds



Disruptive Solution To Parallel Processing



Time to look
at the whole
VisiSoft
System

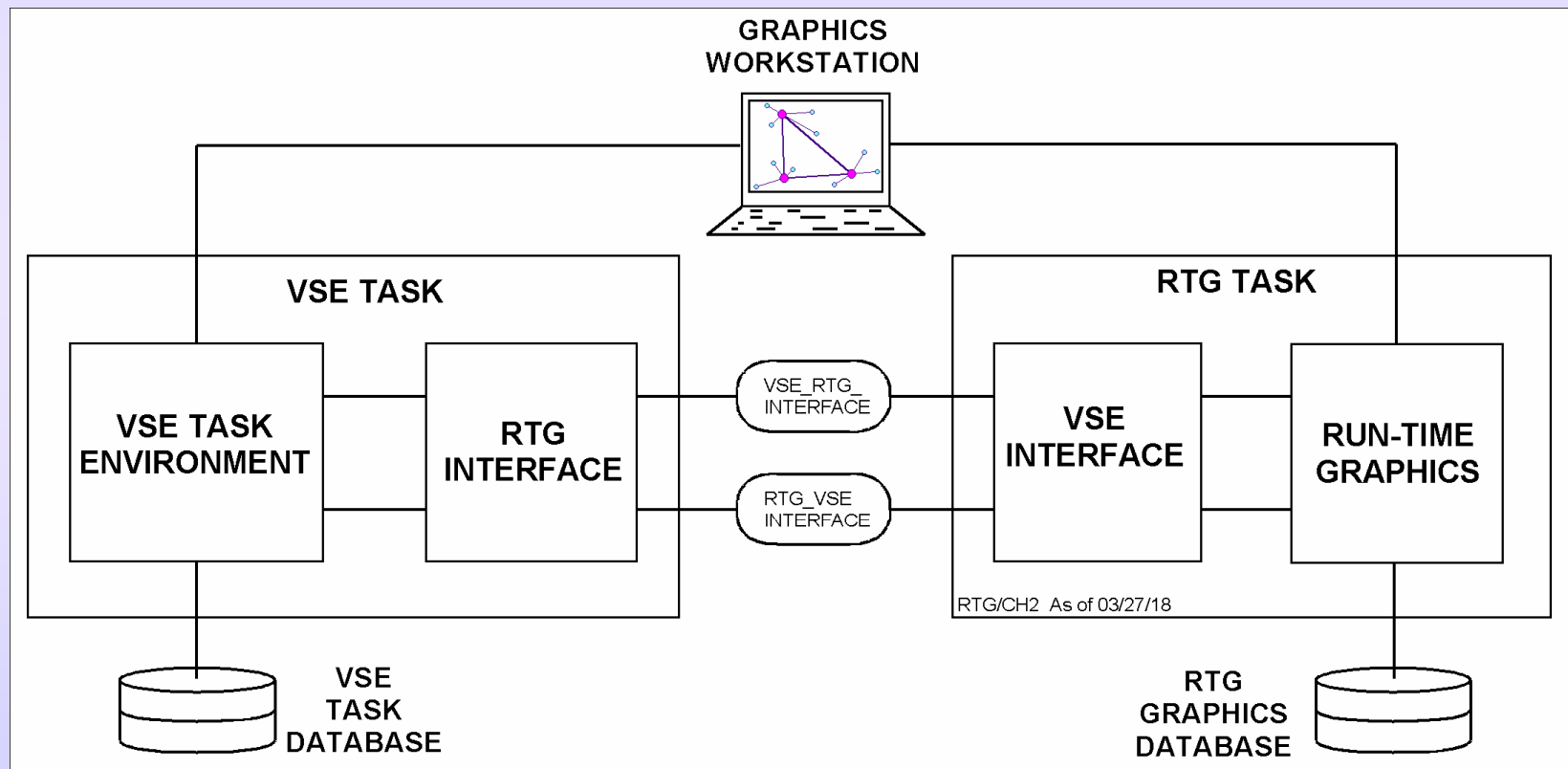




Disruptive Solution To Parallel Processing



First add the Run-Time Graphics (RTG) system
- Making it easy to build *fast complex* graphics

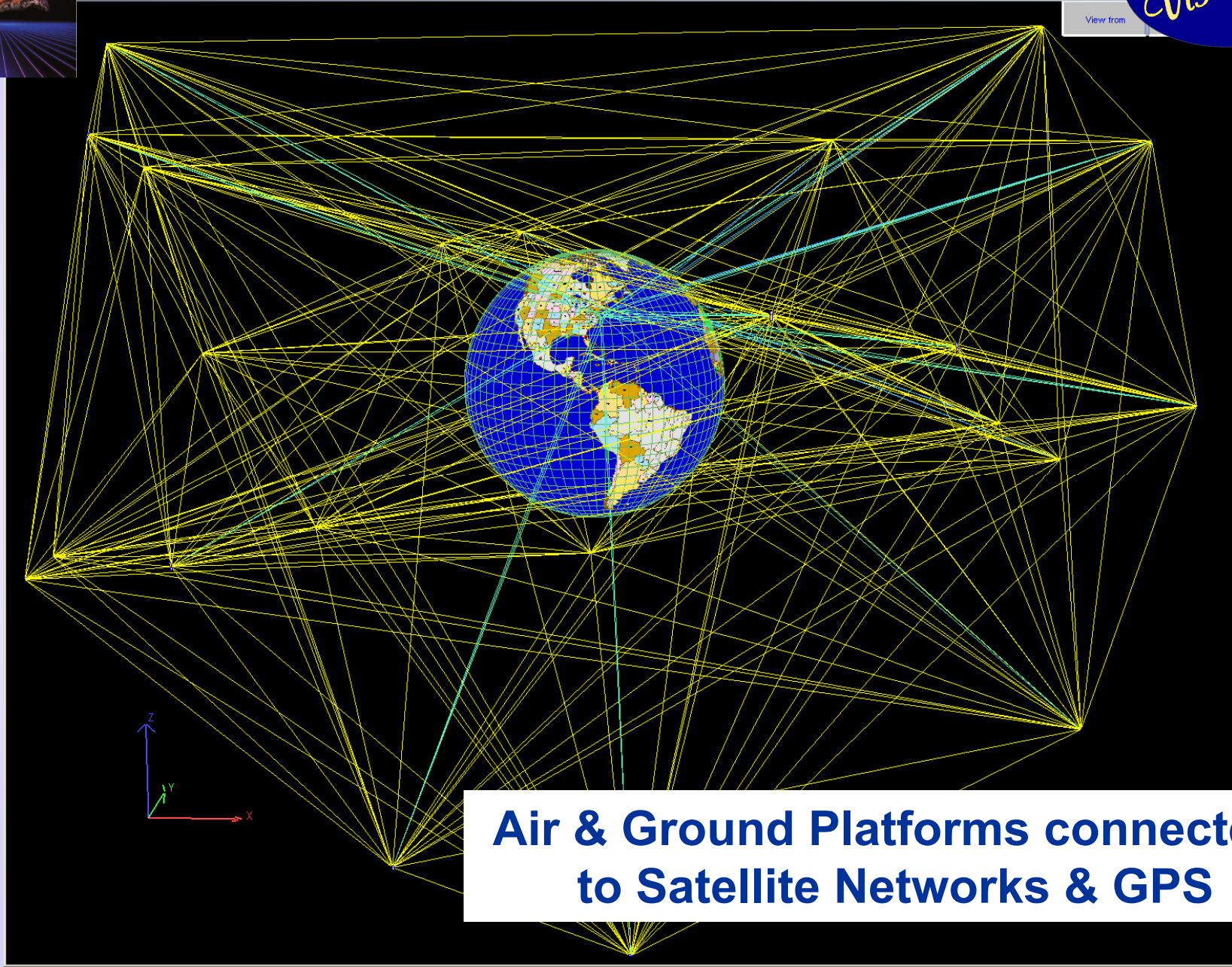


Want to know what's going on in the code? ==>



Time Graphics(RTG)

Disruptive Solution To Parallel Processing



Air & Ground Platforms connected to Satellite Networks & GPS



Disruptive Solution To Parallel Processing



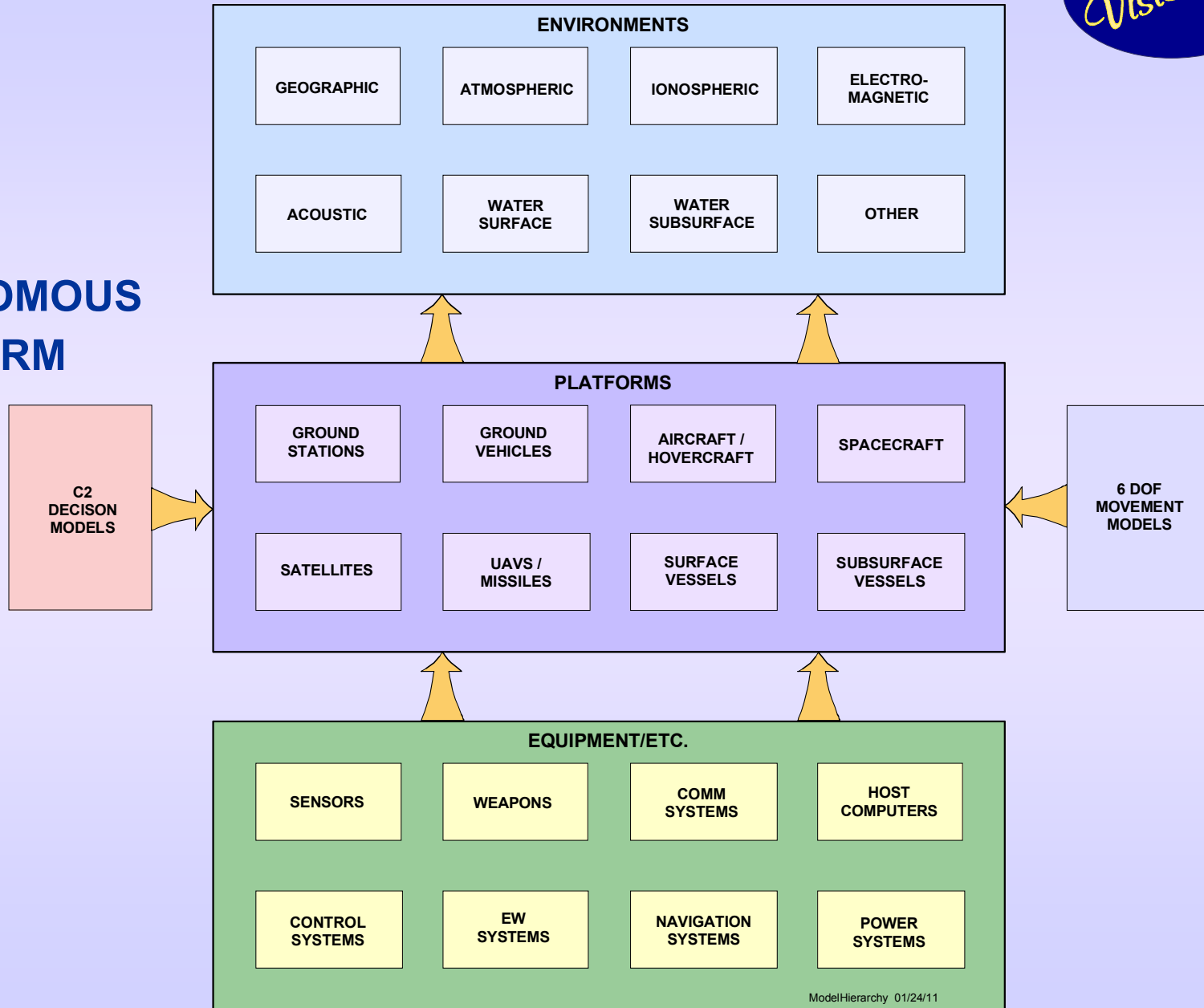
Must be able to *create* complex scenarios - fast!



EXAMPLE OF A MODEL SPACE HIERARCHY



AUTONOMOUS PLATFORM MODEL



ModelHierarchy 01/24/11



Disruptive Solution To Parallel Processing



The screenshot shows a 3D terrain visualization within a software window titled 'VisiSoft'. The terrain is rendered in shades of brown and tan, showing a complex landscape with ridges and valleys. Overlaid on this terrain is a network of lines connecting several points. Most of these lines are red, forming a dense web of connections between points located at various elevations and locations across the terrain. A few lines are green, forming a separate, less dense network. The software interface includes a top menu bar with 'View from' and 'BUTTONS' options, and a vertical toolbar on the left side with various icons for navigation and manipulation. At the bottom, a Windows-style taskbar is visible with various application icons and a system tray.

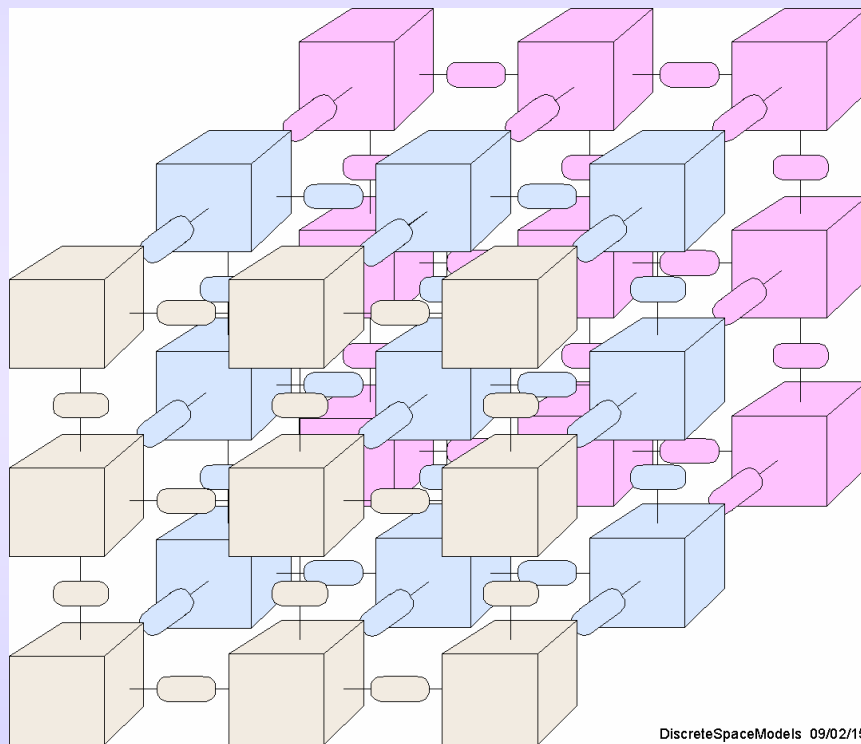
Let's talk about Heterogeneous Cells!



Most Physical Systems Can Be Modeled Using 3-Dimensional Cells

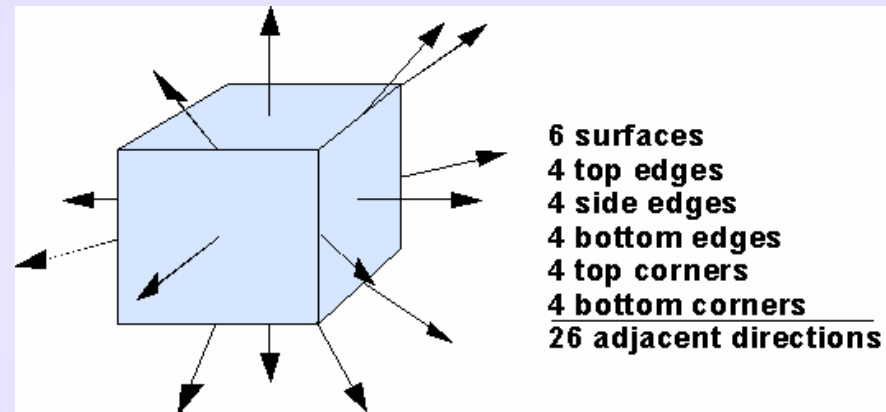


A 3-D matrix of cells



DiscreteSpaceModels 09/02/15

A single resource is shared between the adjacent face of each major cell



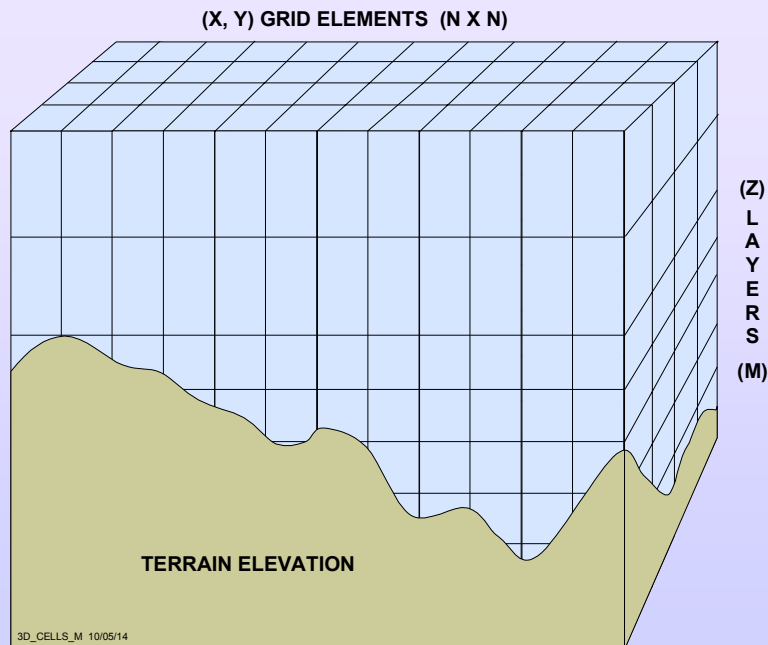
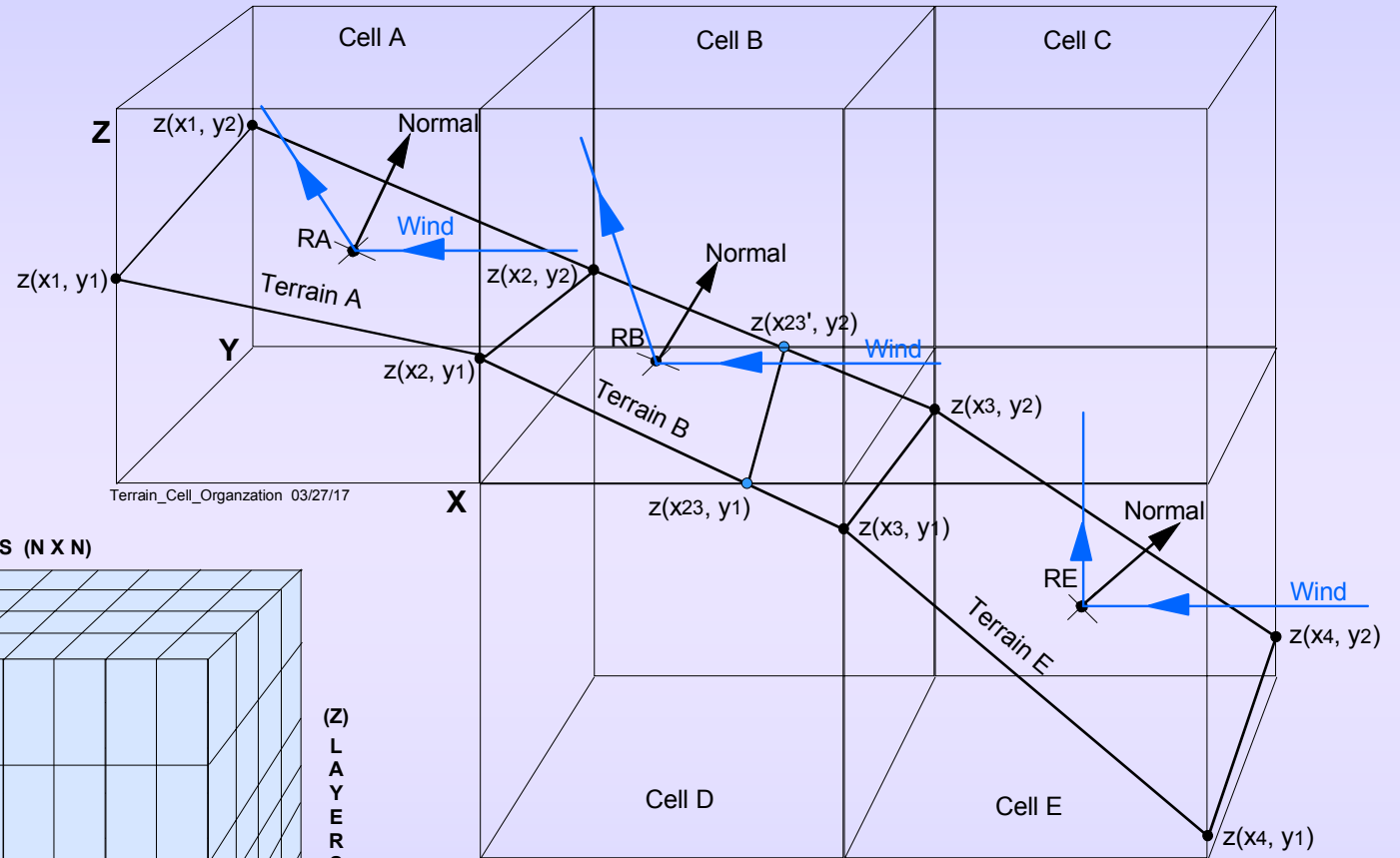
Each cell may contain huge numbers of minor sub-cells

Cells need only interface with adjacent neighbors!



EXAMPLE OF A MODEL SPACE HIERARCHY

WEATHER PREDICTION MODEL

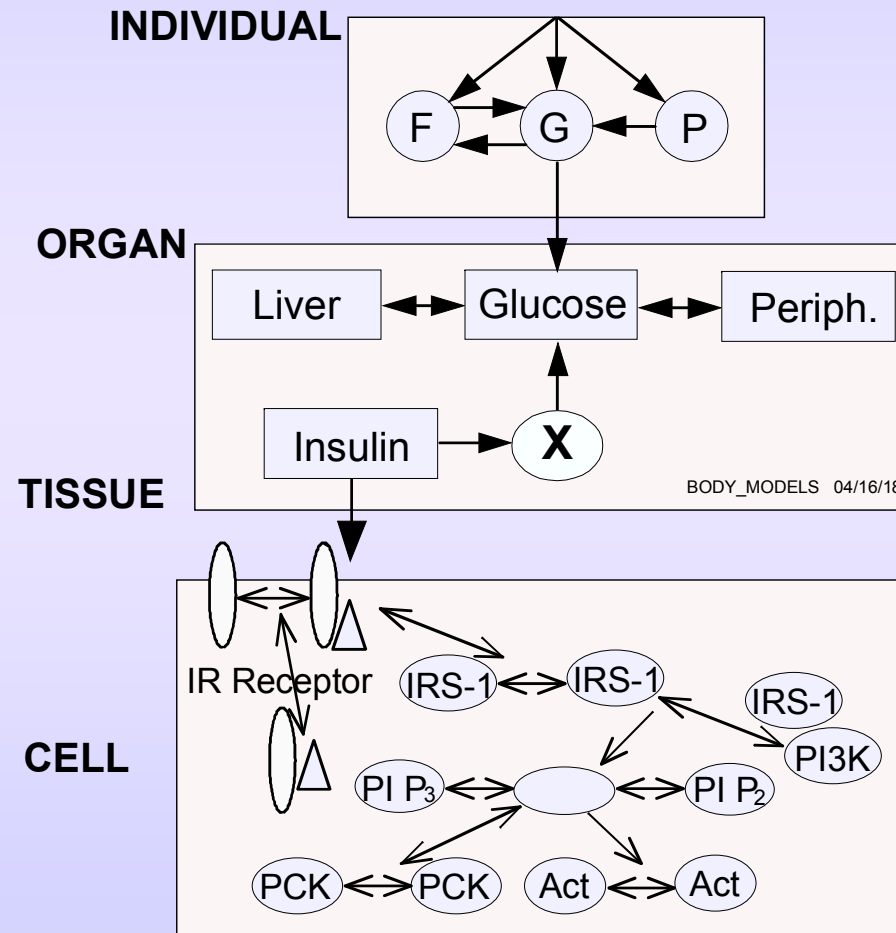




EXAMPLE OF A MODEL SPACE HIERARCHY



A NUTRITIONAL BIOLOGY MODEL**



** Taken from: PLoS Computational Biology, Nov 2009



A SIMPLIFIED NUTRITIONAL BIOLOGY MODEL USING *VisiSoft*

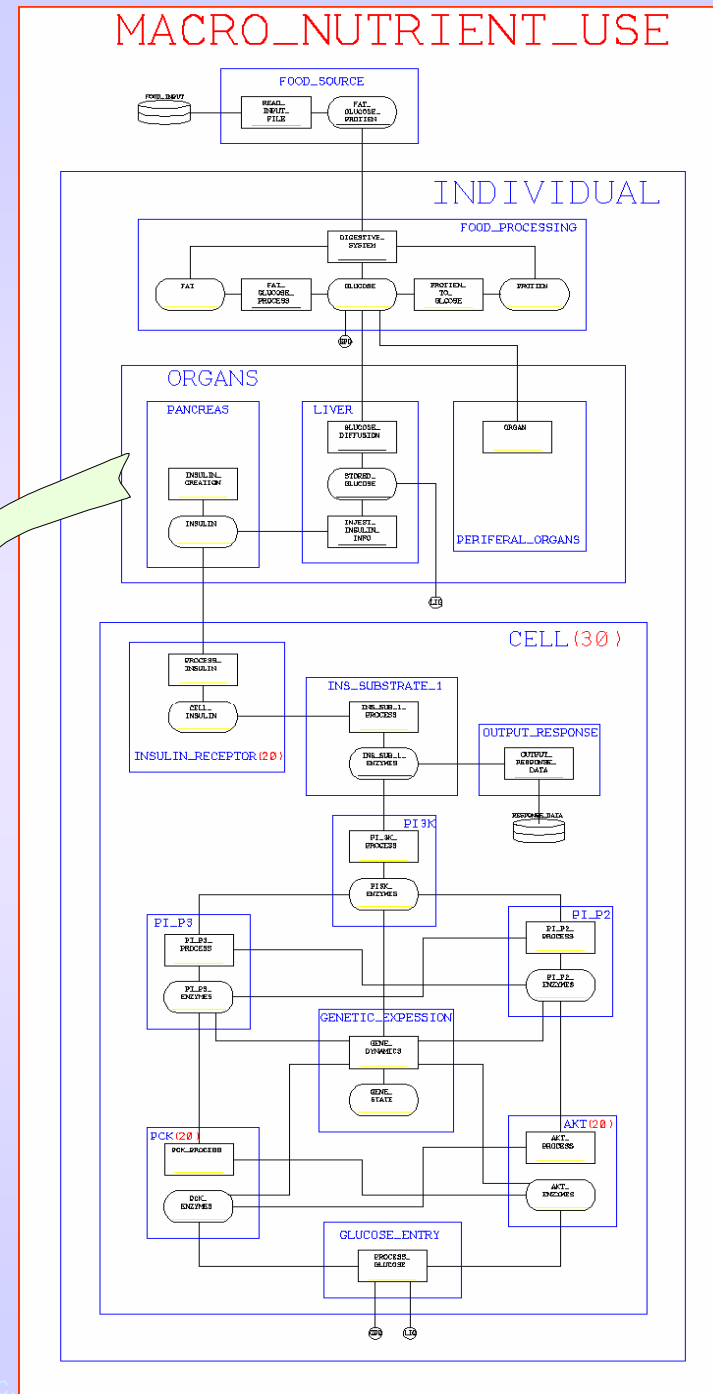
```

    THYROX_IN_BLOOD_P = THYROX_IN_BLOOD * (1 - FLOW_FROM_BLOOD)
                        + FLOW_TO_BLOOD * THYROX_IN_LIVER

    THYROX_IN_LIVER_P = THYROX_IN_LIVER *
                        (1 - FLOW_TO_BLOOD - FLOW_TO_BILE)
                        + FLOW_FROM_BLOOD * THYROX_IN_BLOOD

    THYROX_IN_BILE_P = THYROX_IN_BILE + FLOW_TO_BILE * THYROX_IN_LIVER

    IF TIME_IN_MINUTES IS LESS THAN 301
        SCHEDULE LIVER_PROCESS IN 10 MINUTES
  
```

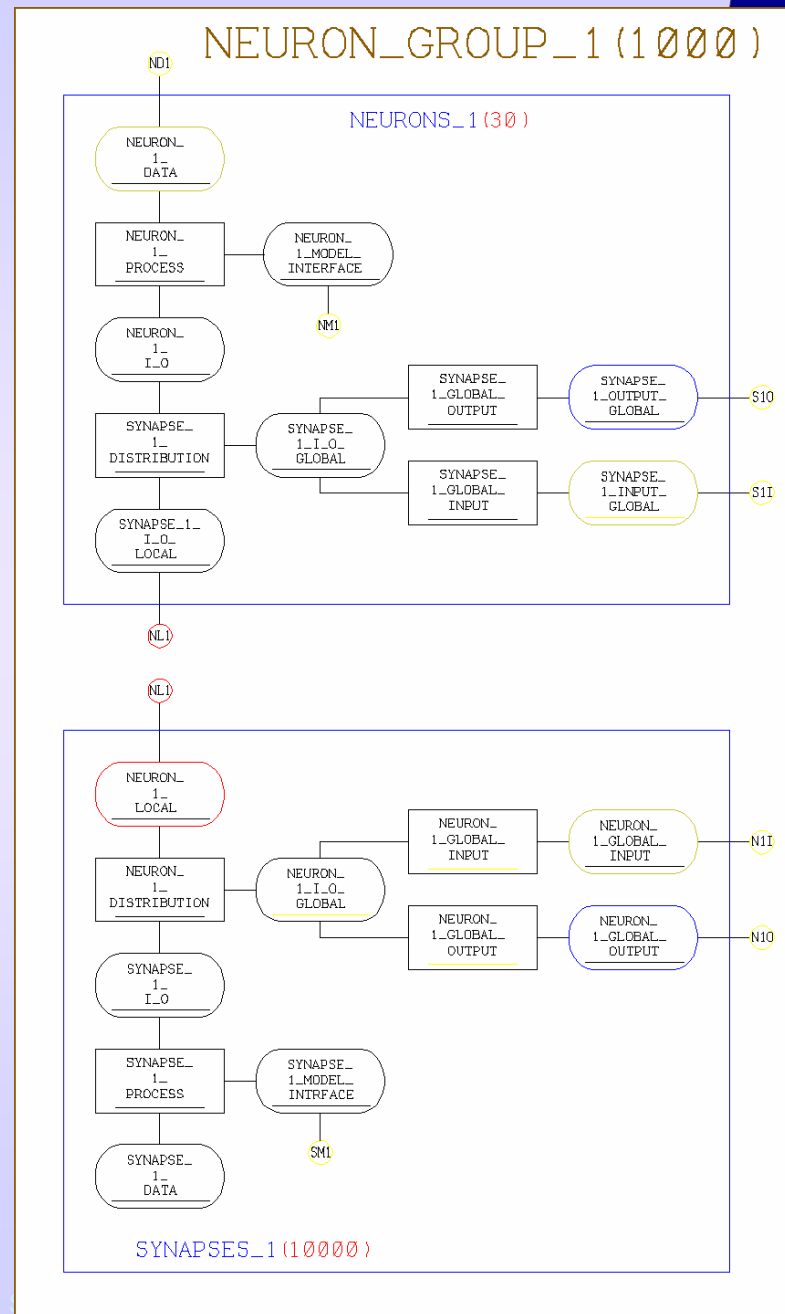
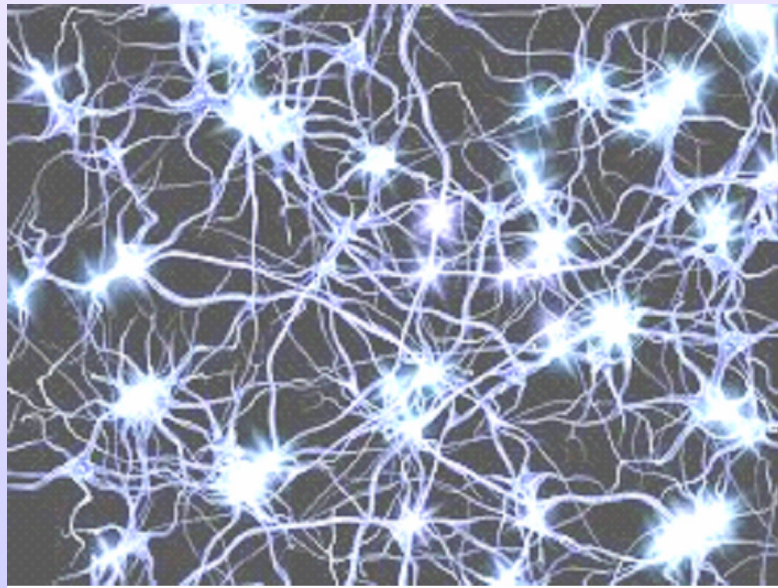




EXAMPLE OF A MODEL SPACE HIERARCHY



GREATLY SIMPLIFIED NEURON - SYNAPSE SUB-MODEL ARCHITECTURE

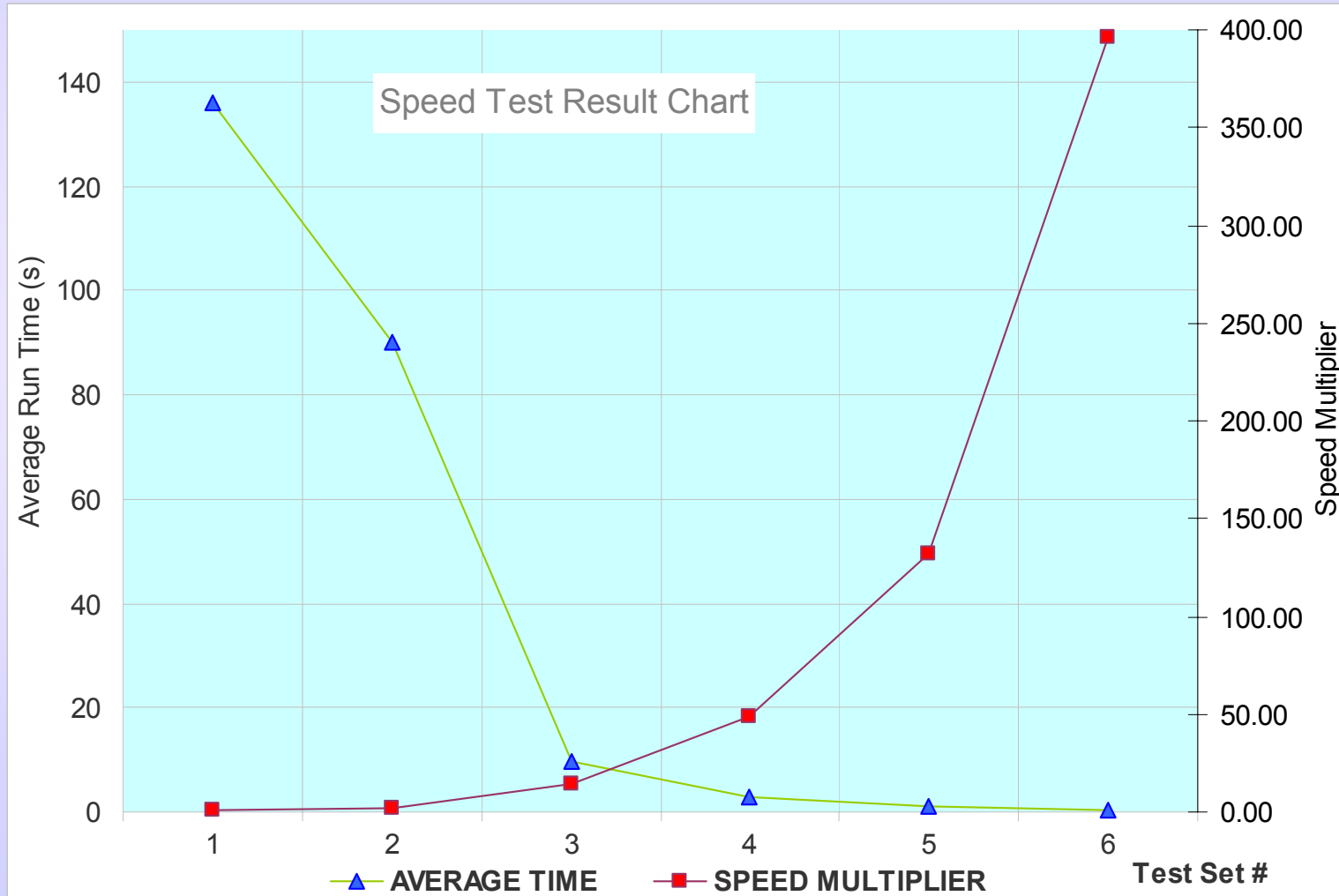




*If you use **VisiSoft** to build complex
Real-Time Control Systems & Simulations
on Parallel Processors
you can save many orders of magnitude
of time and money!*

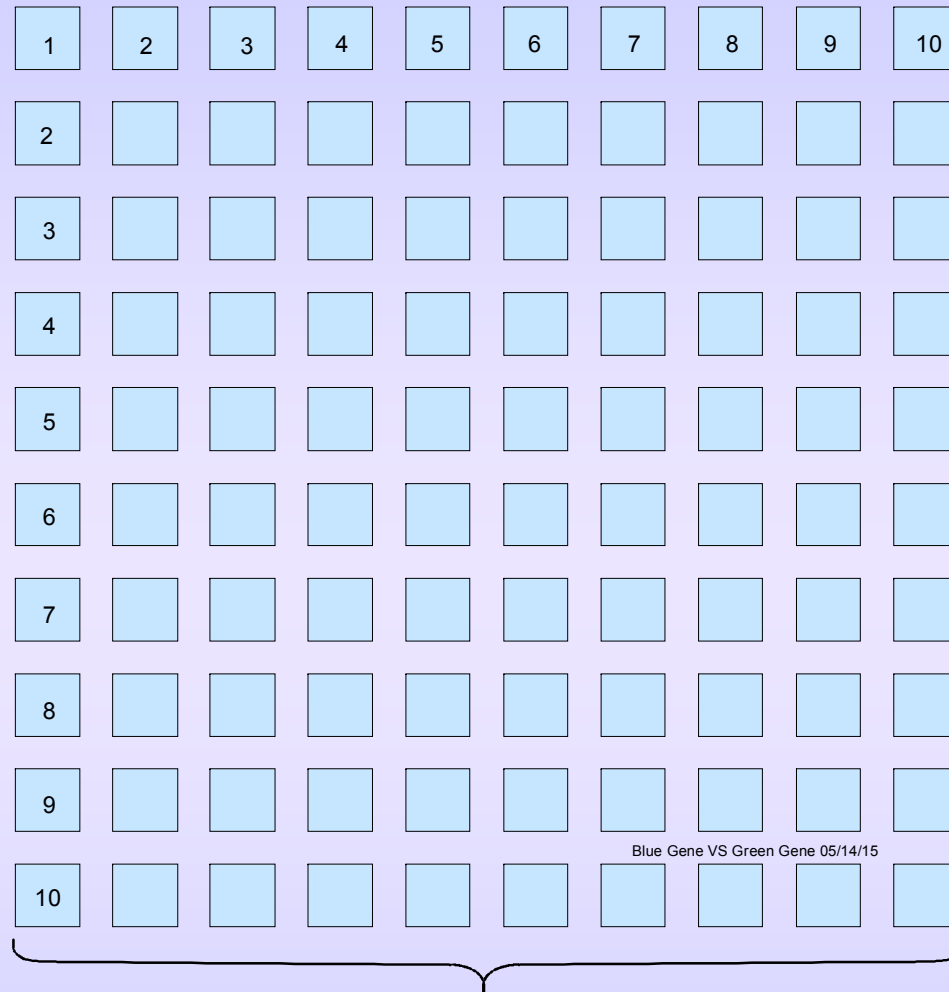


SINGLE PROCESSOR SPEED COMPARISONS - GAIN 100⁺ X SPEED WITH VISISOFT






GO FROM 100 RACKS TO 1 RACK



The IBM Blue Gene - Using Standard Languages - 100 Racks - 1,638,400 Processors
5,000 Sq Ft. - 8,000 KW

Versus

 The Green Gene Machine - Using VisiSoft - 1 Rack - 2300 Processors
16 Sq Ft. - 32 KW



***What does that do to
memory boundary crossing delays?***

***What about 2 additional
orders of magnitude?***



It doesn't stop there!

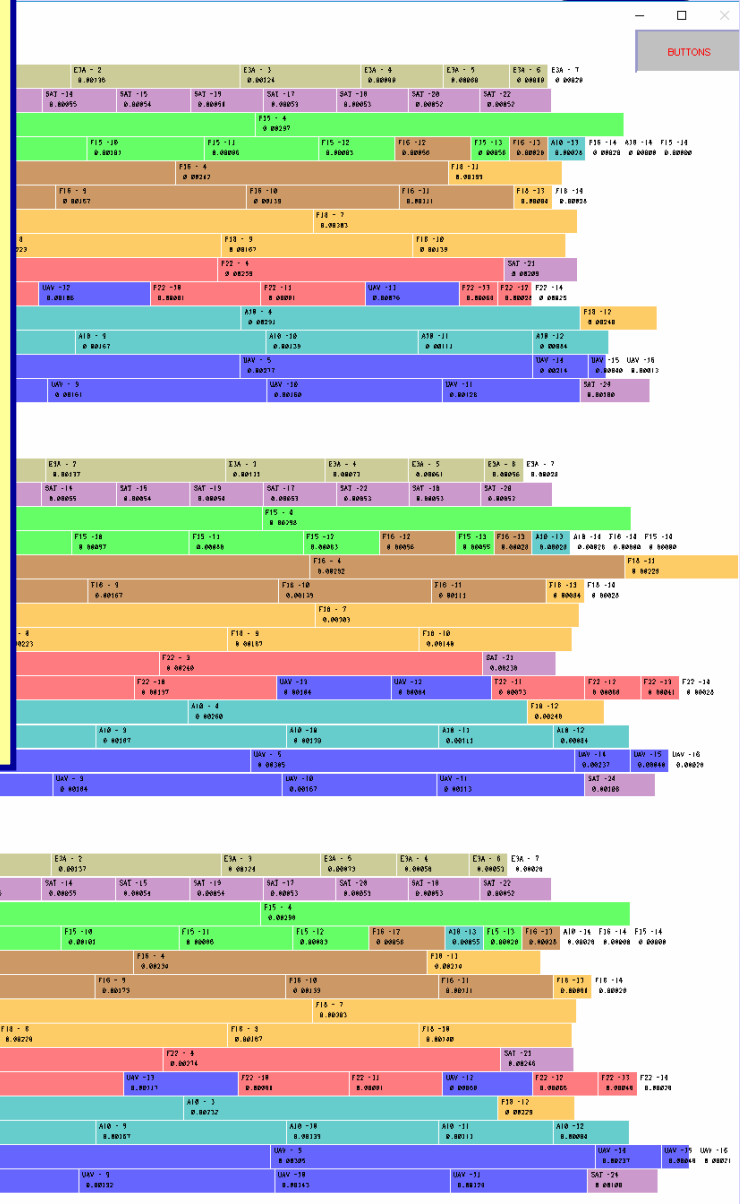
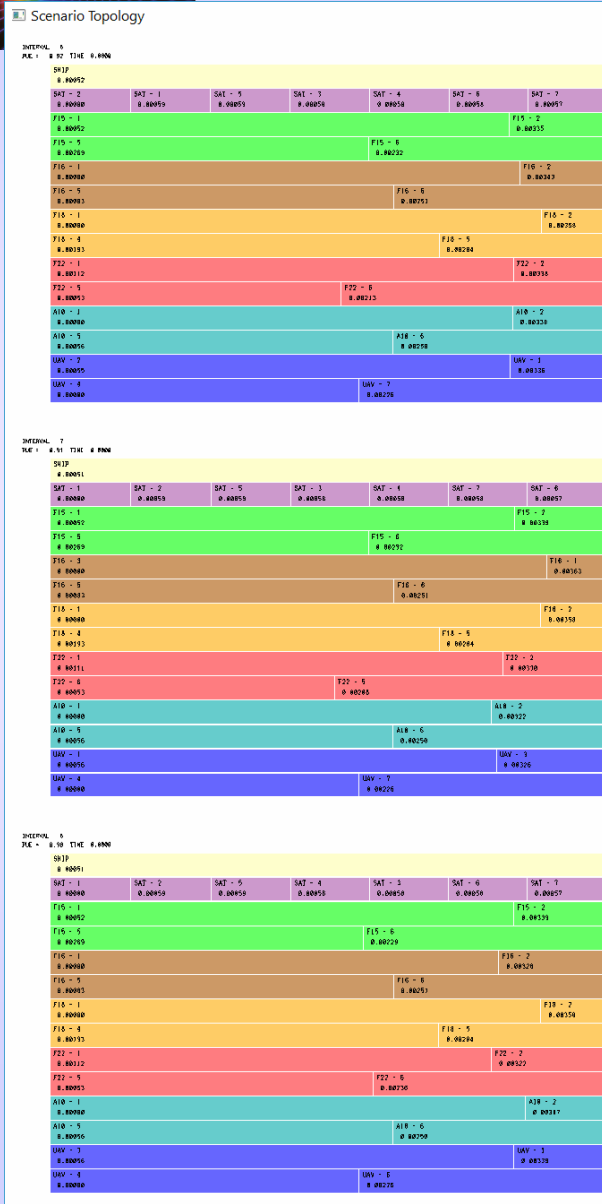
We can shrink it more by mapping our architectural drawings onto the hardware so the software does not move!

What about a total of 4 to 6 orders of magnitude?

Know what that does to energy utilization?



GLOBAL PLANNER
153 Platforms
12 Hour Scenario
Single Processor
24 Seconds
TIME PROFILER
14 Processors
2 Seconds
Using instanced
models,
one can achieve
> 95%
Processor
Utilization
Efficiency (PUE)





And, it doesn't stop there!

We can shrink it even more – using our hierarchical data structures to support fast heterogeneous models of time & space (cells).

What about a total of 6 to 8 orders of magnitude* ?

Know what that does to the computer field?

****Depends on the application***



And still - not finally,

***Use VPOS - a tailored
Parallel Processing OS
- Written in VisiSoft.***

And get rid of big time wasters, e.g.:

- Cache Coherency***
- Thread Synchronization***
- Stacks***
- Etc.***



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