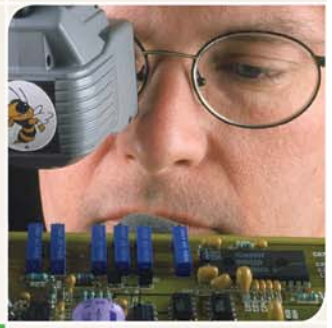
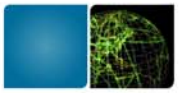





GLIMPSES: Memory and program behavior estimation for SPEs

Jaswanth Sreeram, Ling Liu, Santosh Pande

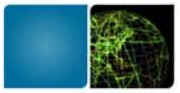
Georgia Tech College of Computing


Motivation

"Prototyping large codebases for porting to SPEs is challenging"

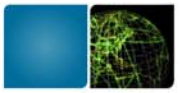
"Need a way to quickly evaluate program behavior and its suitability for SPEs" – Important for legacy code/reuse


Motivation (contd)

- Porting large codebases to SPEs is challenging
  - Limited local store
  - High branch penalty
  - Geared towards vectorizable code
  - Code/data partitioning is not trivial
  - SPE-SPE, SPE-PPE interactions

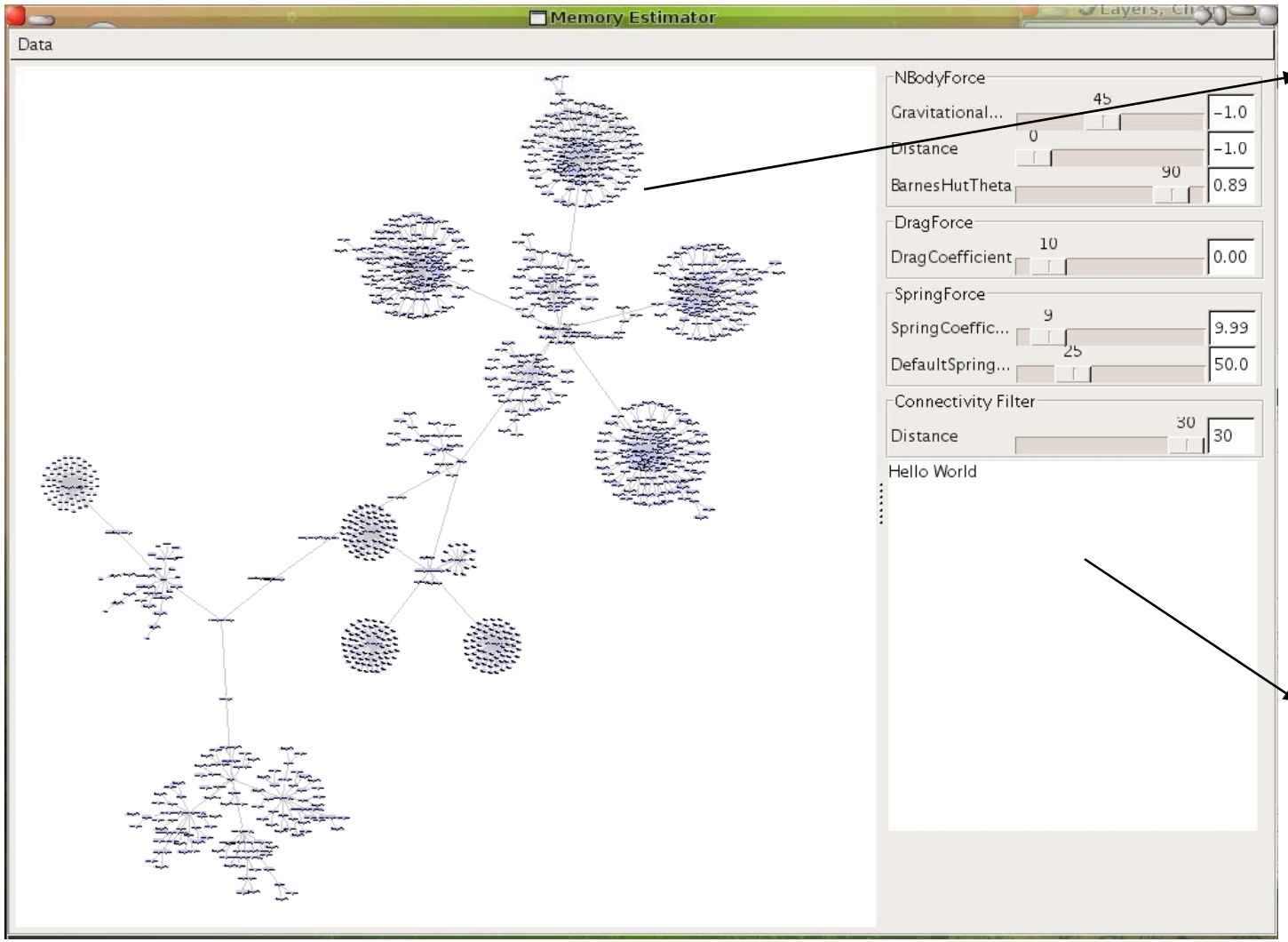
- Provide programmer with tools to
  - Understand dynamic program behavior
  - Quickly construct candidate partitions for SPEs
  - Evaluate/Quantify partitions' suitability for SPEs


GLIMPSES: Tool Overview

- Dynamic Call Graphs
- Memory Requirements
  - Dynamic
  - Analytical
- Memory Access Patterns
  - Locality (spatial, temporal, neighbor affinity)
- Partitioning
  - Criteria based estimates
- Visual, interactive

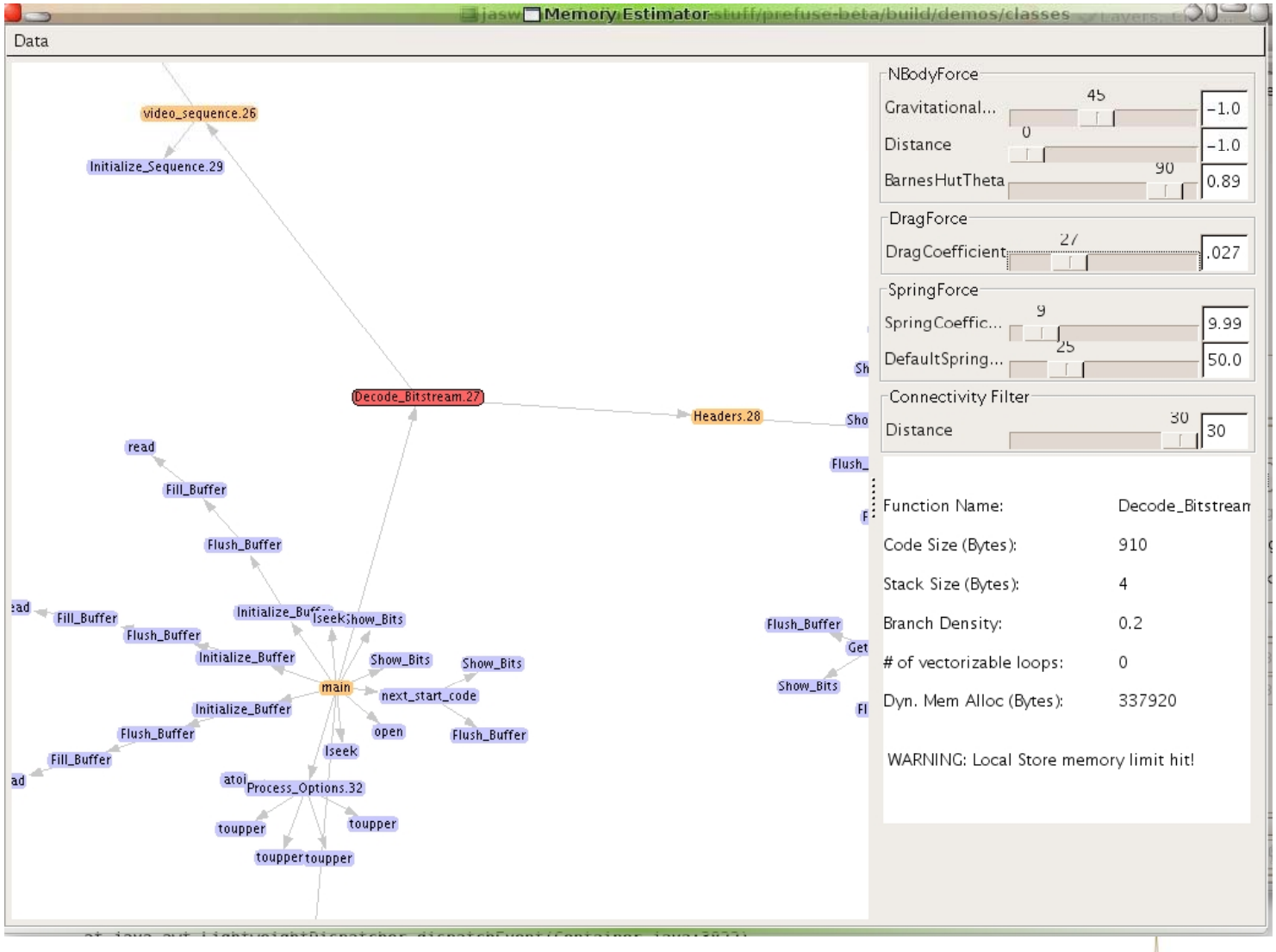
Dynamic Call Chains



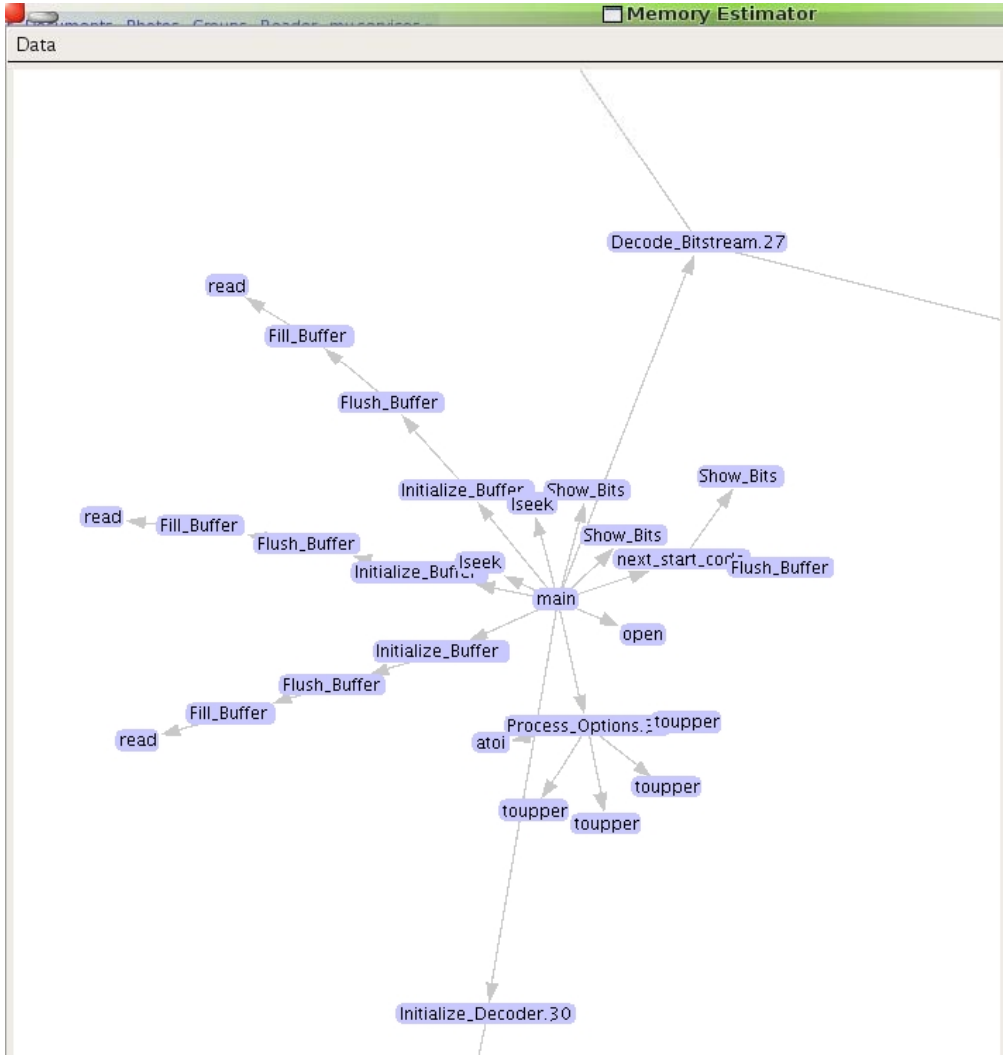
Graph Visualization Area

Results Display Panel

Call chains...contd

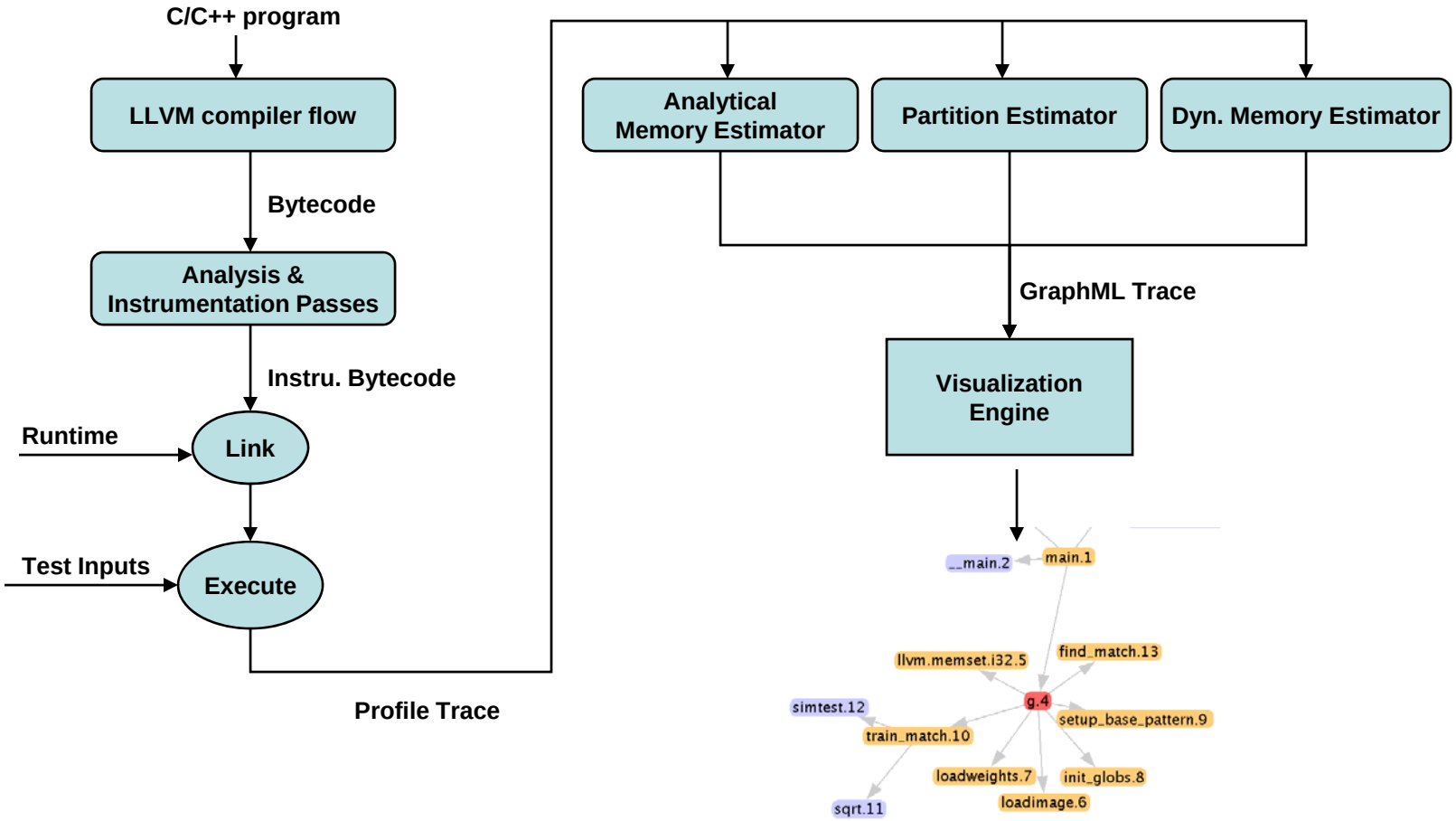


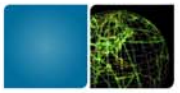
Mpeg-2 Decode



- Zoom view
- Shows dynamic call chains for a program run (in this case the program is mpeg2-decode)

GLIMPSES


C/C++ program
LLVM compiler flow
Bytecode
Analysis & Instrumentation Passes
Instru. Bytecode
Runtime
Link
Test Inputs
Execute
Profile Trace
Analytical Memory Estimator
Partition Estimator
Dyn. Memory Estimator
GraphML Trace
Visualization Engine
__main.2
main.1
llvm.memset.i32.5
find_match.13
simtest.12
g.4
setup_base_pattern.9
train_match.10
loadweights.7
init_globs.8
sqrt.11
loadimage.6


Memory Behavior

- Estimate static and dyn. memory usage
  - Code, stack and heap (per function)
  - Usage < SPE LS limit ?
- Estimate function attributes
  - Branch density
  - Number of Auto-vectorizable loops
- Analytical estimation
  - Detect program objects affecting dynamic memory behavior
  - Show correlation between these program objects and memory usage.
    - Construct an arithmetic expression for amount of memory allocated, in terms of inputs or other program objects

Analytical Estimator : Mpeg2 example

Code segment

```
for (……)
{
if (cc==0)
     size = Picture_Width*Picture_Height;
   else
     size = Chroma_Width*Chroma_Height;

   if (!(backward_reference_frame[cc] =
(unsigned char *) malloc(size) ))
     Error(…);

   if (!(forward_reference_frame[cc] =
(unsigned char *) malloc(size) ))
     Error(…);
}
```

Result

__Malloc_size__1 = 1024

__Malloc_size__2 = 0 + Coded_Picture_Width*Coded_Picture_Height

__Malloc_size__3 = 0 + Coded_Picture_Width*Coded_Picture_Height

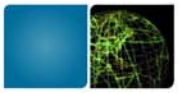
__Malloc_size__4 = 0 + Coded_Picture_Width*Coded_Picture_Height

__Malloc_size__5 = 0 + Chroma_Width*Chroma_Height

__Malloc_size__6 = 0 + Chroma_Width*Chroma_Height

__Malloc_size__7 = 0 + Chroma_Width*Chroma_Height

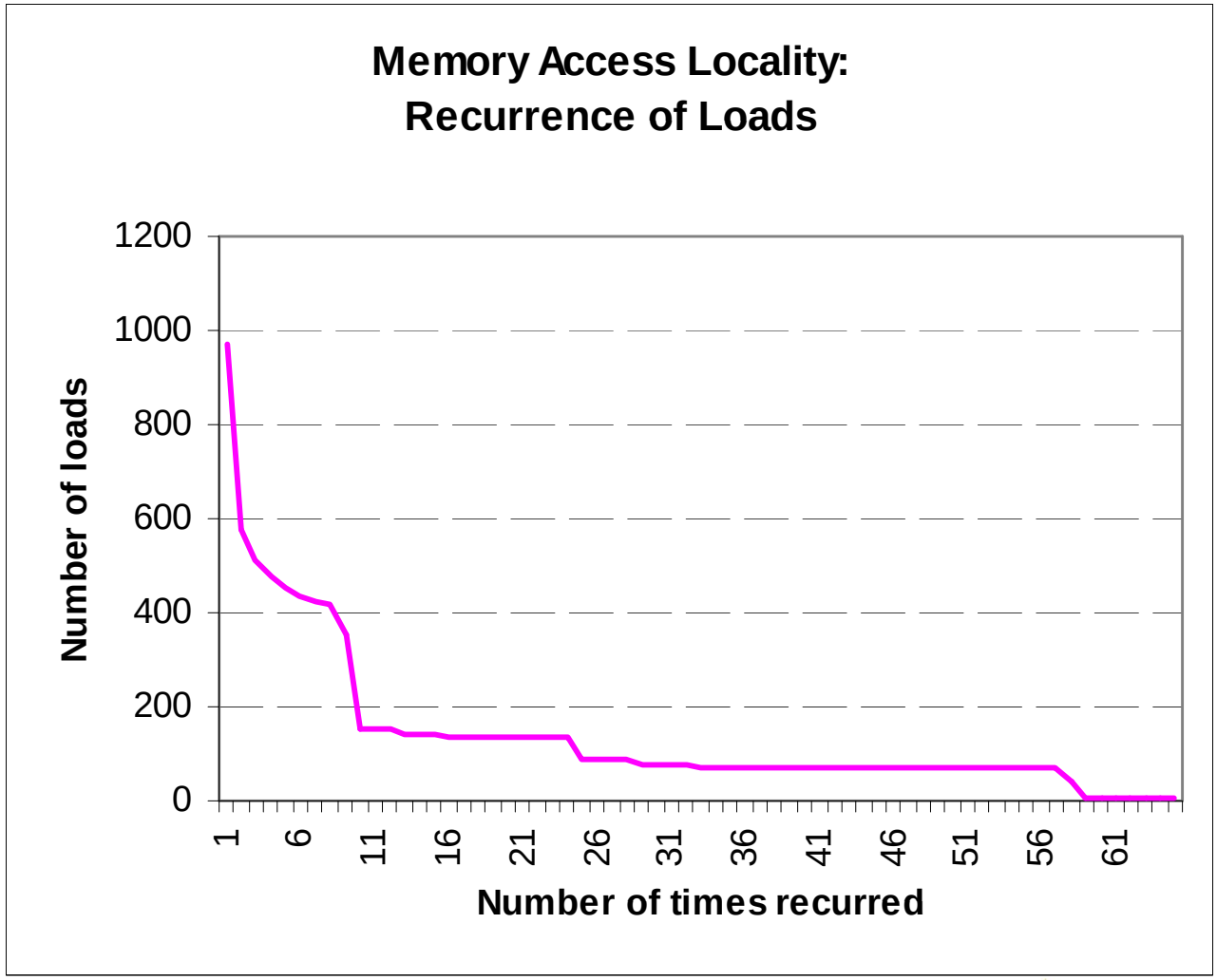
__Malloc_size__8 = 0 + Chroma_Width*Chroma_Height

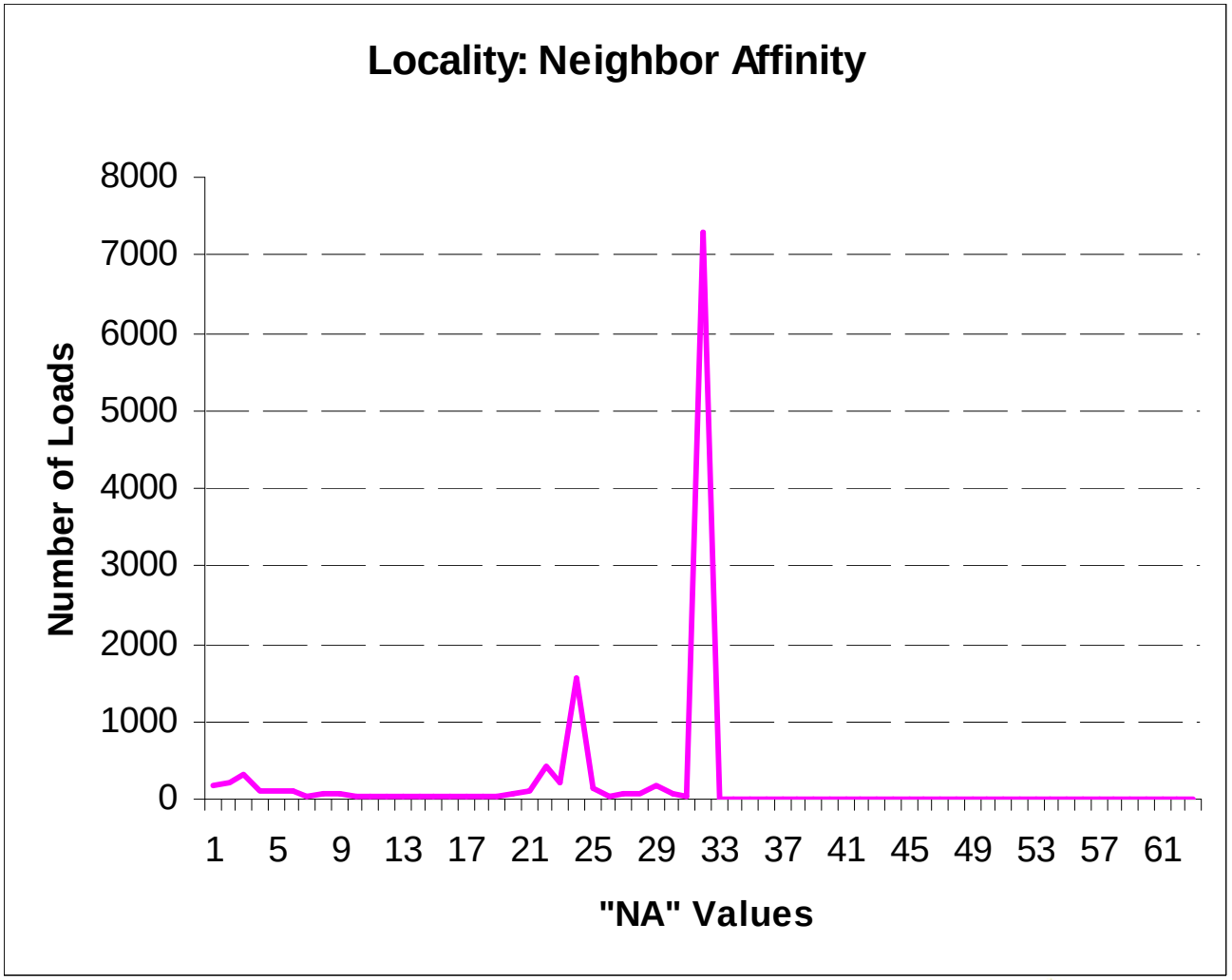

Memory Access Patterns

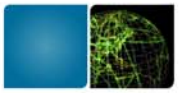
- Locality metrics for loads/stores
  - Spatial Locality
    - "Loads to different addresses in a spatial window"
  - Temporal Locality
    - "Loads to same address in a time window"
  - Neighbor Affinity
    - "Loads to addresses within a space and time window"

Locality Measures (mpeg2decode)



Locality measures: Affinity

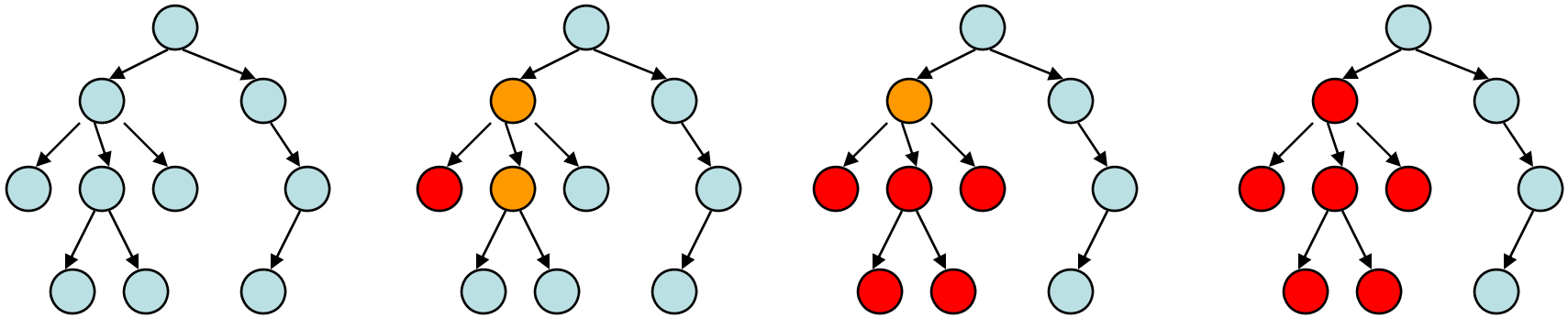



Program Partitions

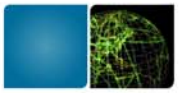
- Provide programmer with possible partition candidates
  - Can be based on criteria:
    - Memory consumption
    - Memory reference behavior
    - Branch density
    - Auto-vectorizable loops
    - Aliasing
    - Combination (a “rank” metric)
  - Does not assume code/data overlays

Partitioning



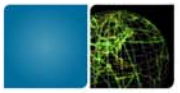
- Start with earliest leaf node in dyn. call graph in a partition
- Try to add its parent to the partition
  - Try to add all of parent's children to the partition
  - If they can be added, try to add parent to partition.
- Try to add parent's parent to partition

- Estimates only: No code generation
- Programmer to take care of "cloning".
- Can produce interprocedural, context sensitive alias information.
  - Given two partitions, can they alias each other's data ?


Status

- Several features/improvements planned
  - Alias Analysis information for refining partition-set
  - Alias Analysis information for data pinning/prefetching opportunities.
  - Leverage **D**ata**S**tructure**A**nalyses for smart memory allocation on SPUs
- Tested on
  - Workloads from SPECINT
  - Workloads from mediabench
  - ODE (Open Dynamics Engine)
- Beta version to be released shortly.


The End

Email contact:

jaswanth@cc.gatech.edu