UPC Runtime Layer

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The Big Picture

The Runtime layer handles everything that is both:

1) Platform/Environment specific

—So compiler can output one version of code for all platforms.

2) But also specific to UPC

—So GASNet can remain language-independent.

Runtime Layer Laundry List

1) Shared pointer representation and manipulation

2) Pthread creation and management

3) Memory Management

4) Synchronization

5) Initialization code

Supported Runtime Environments

2 Main Axes:

1) Threads vs. Processes

2) Network vs. Shared Memory vs. both

- — Also; network vs. local synchronization mechanisms

We will support:

- — Threads on a single SMP (all shared memory)
- — Processes on a single SMP (all shared memory)
- — Processes w/network (all network)
- — Threads w/network (use both)

We won’t support (at least for now)

- — Processes on SMP & network (using both)
  - — Will only use network communications

Implementation goals

Speed: compile time resolution instead of run-time checks wherever possible.

Parsable by compiler (for compilers that generate straight to assembly)

—Inline functions instead of macros where possible.

Clean, maintainable implementation

—But have it done yesterday

Shared Pointer Representation

```
struct naïve_shared_ptr {
   void * addr;
   uint   thread;
   uint   phase;
};
```

- **Provide phaseless shared pointer type (for both phaseless and default cyclic).**

  —Can omit phase field.

  —If pure shared memory, this can just be a pointer

- **64 bit platforms: may be able to stuff some fields into unused top bits of pointer.**
- **Using offset instead of address may save space**

  —But might make casts to local slower…

- **Solution: provide abstract type and operations.**

Thread-specific data

All unshared global & static declarations must be have a copy per pthread.

Solution #1: Put all variables in a big struct, and make 1 copy of it per thread.

—Need to effectively eliminate separate compilation (slow).

—Data no longer initialized by linker

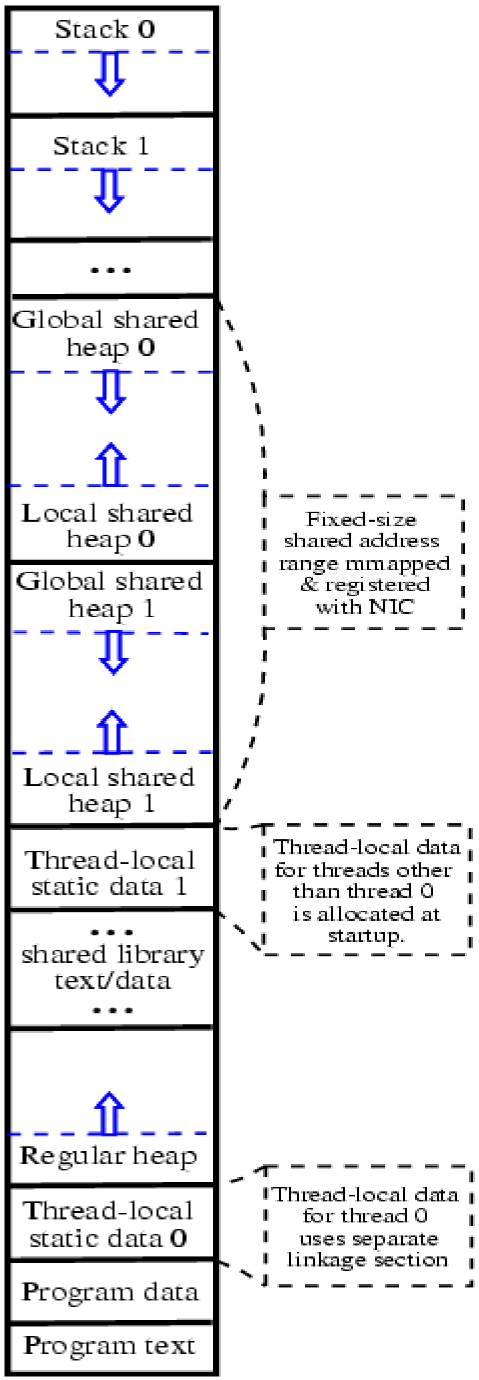
—Object files not readable by nm, etc.

Solution #2: Put all variables in single link section—make 1 copy of section per thread, and use pointer & offset into section to reference variables.

—Solves initialization, separate compilation, object format.

—But involves nonstandard compiler and linker directives.

Heap Management



Fixed-size shared address range mmapped & registered with NIC

Thread-local data for threads other than thread 0 is allocated at startup.

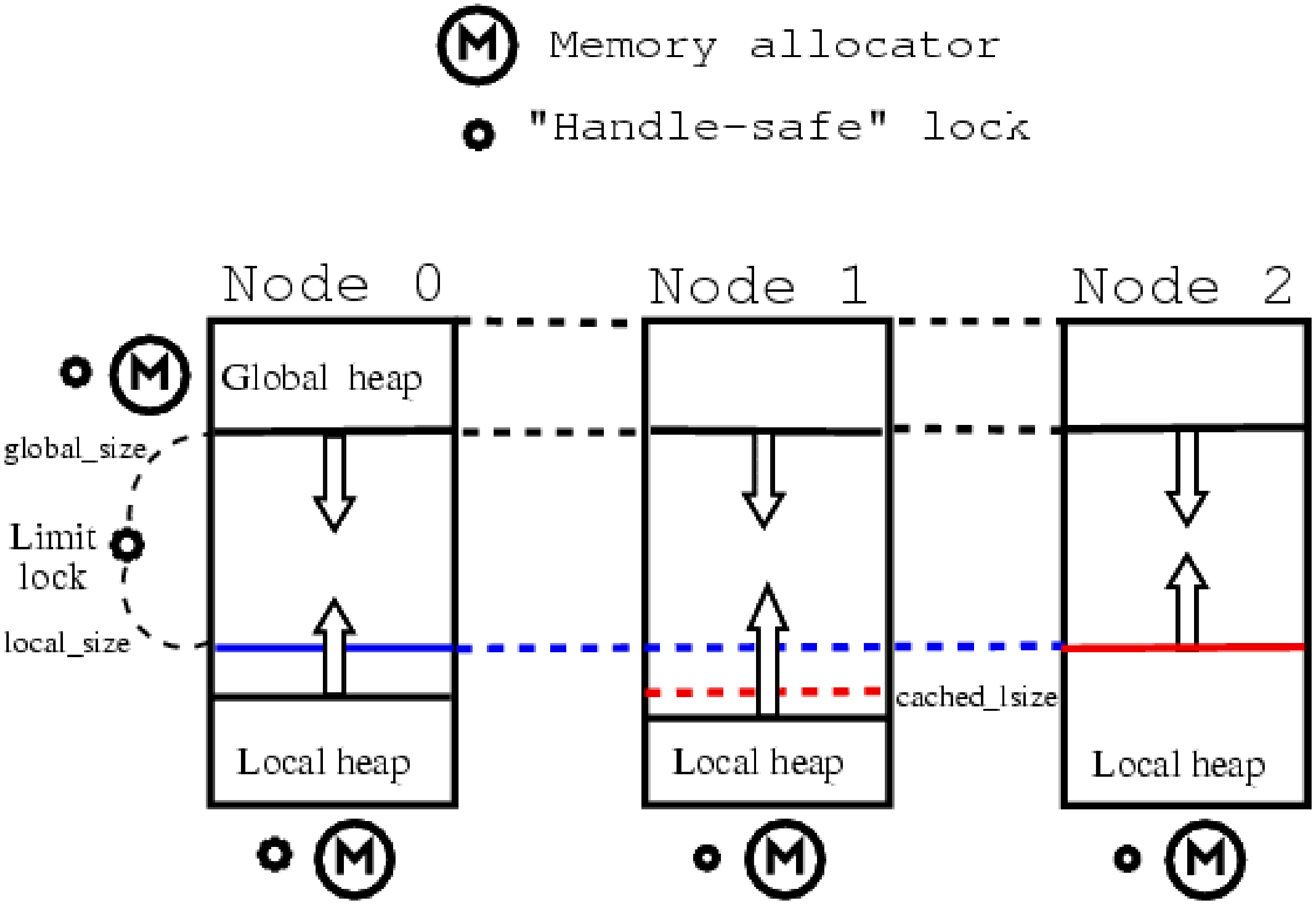
Thread-local data for thread 0 uses separate linkage section

GASNet provides a single, fixed network-accessible shared memory region to the Runtime.

The Runtime must divide it among threads, and manage separate local and global heap for each thread.

Also must prevent regular C heap from expanding into shared region: hook malloc/free to our own, bounded heap.

Shared Memory Allocation



Synchronization

Pure Shared Memory environments:

—Runtime provides synchronization via pthreads or System V IPC mechanisms.

Networked environments:

—GASNet provides synchronization across processes via the network

—Runtime provides it between threads in the same process.

Allocating/Initializing Shared Data

Initialization of shared data can be tricky:

```
extern shared int array[THREADS];
shared int *p = &array[8];
```

Thread-specific data: can no longer trust linker to initialize addresses for unshared global/static pointers:

```
int foo;
int *pfoo = &foo;
```

Solution: per file initialization functions to handle complex cases

—Must be able to run in arbitrary order

—Runtime may provide helper functions for compiler.

Implementation Plan

1) Processes with shared memory:

—In progress: should be done by mid-June.

—Allow compiler correctness testing and optimization work to proceed.

2) Processes with network

—Less than a month additional effort.

—Allow GASNet testing, and ports to multiple networks.

3) Threads support

—Trickiest implementation issues.

4) Ports to other platforms trivial given a GASNet implementation for the network.

—Mainly compiler/linker-specific hooks for TSD.