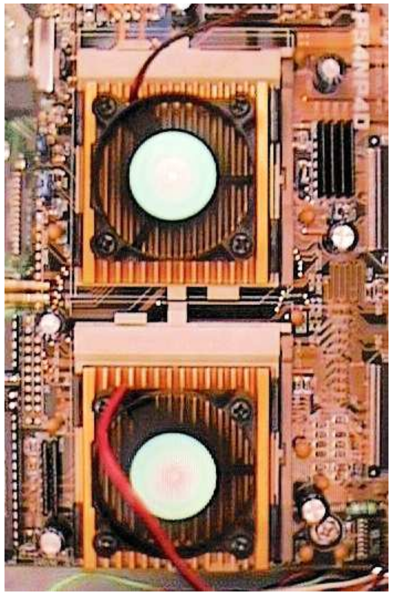

SHMAPERS

SHared Memory Adapter for Parallel Execution and Rapid Synchronization

AFAPI

Aggregate Function
Application Program Interface

Version 960801

C Reference Card

http://garage.ecn.purdue.edu/~papers

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NOTE: SHMAPERS is designed to run on systems supporting UNIX System V shared memory (e.g., Linux). Generally, best performance is obtained when running on a lightly loaded SMP with **NPROC** equal to the number of processors. Each operation can cause up to O(**NPROC**) shared memory accesses.

All processors act synchronously to perform each `p_` prefix operation. Any processor can independently call an asynchronous signal routine (`s_` prefix). Simultaneous use of `p_` and `s_` routines is illegal.

Include files

afapi.h
C header file for general use

inline.h
Definitions of inline primitives (`p__` and `s__`)

Data Types

GCC Declaration	Type Suffix
int (barrier group bit mask)	**bar**
int (boolean)	**1u**
char	**8**
unsigned char	**8u**
short	**16**
unsigned short	**16u**
int	**32**
unsigned int	**32u**
long long	**64**
unsigned long long	**64u**
float	**32f**
double	**64f**
void *	**ptr**
(byte block, compressed)	**z**

$\delta \in \{\mathbf{1u}, \mathbf{8}, \mathbf{8u}, \mathbf{16}, \mathbf{16u}, \mathbf{32}, \mathbf{32u}, \mathbf{64}, \mathbf{64u}\}$

$\gamma \in (\delta \cup \{\mathbf{32f}, \mathbf{64f}\})$

$\beta \in (\delta \cup \{\mathbf{bar}, \mathbf{ptr}\})$

$\alpha \in (\delta \cup \{\mathbf{bar}, \mathbf{32f}, \mathbf{64f}, \mathbf{ptr}\})$

p_α
AFAPI portable type name; e.g., **unsigned int** is **p_32u**, **double** is **p_64f**, **char** is **p_8**

Constants and Special Variables

(const int) NPROC
Number of PEs; compile-time constant

(const int) IPROC
PE number, 0..**NPROC**-1

(const int) CPROC
PE number of console/control PE

AFAPI Aggregate Functions

Control

int p_init(void)
Check-in with AFAPI; return 0 for no error

void p_exit(void)
Check-out with AFAPI

int p_confirm(void)
Confirm that AFAPI is functioning correctly; return 0 for no error

Primitives

void p_wait(void)
Barrier synchronization

p_bar p_waitbar(p_1u f)
Bit mask with 2^k set *iff* PE*k* **f**!=0

p_1u p_any(p_1u f)
Was **f**!=0 on any enabled PE?

p_1u p_all(p_1u f)
Was **f**!=0 on all enabled PEs?

Communications

p_α p_bcastGetα(void)
Broadcast get value from sending PE

void p_bcastPutα(p_α d)
Broadcast put **d** from this PE

void p_bcastGetz(void* a, int n)
Broadcast get **n** bytes into address **a**

void p_bcastPutz(void* a, int n)
Broadcast put **n** bytes from address **a**

p_α p_putGetα(p_α d, int s)
Put **d**, get (return) **d** from PE **s**

void p_gatherα(p_α *p, p_α d)
Gather an array **p[**i**]** = **d** from PE i

p_α p_scatPutα(p_α *p)
Scatter put so PE i gets **p[**i**]**

p_α p_scatGetα(void)
Scatter get

Associative Reductions

p_β p_reduceAndβ(p_β d)
Bitwise AND of **d** from each PE

p_β p_reduceOrβ(p_β d)
Bitwise OR of **d** from each PE

p_β p_reduceXorβ(p_β d)
Bitwise XOR of **d** from each PE

p_α p_reduceMinα(p_α d)
Minimum of **d** from each PE

p_α p_reduceMaxα(p_α d)
Maximum of **d** from each PE

p_γ p_reduceAddγ(p_γ d)
Sum of **d** from each PE

p_γ p_reduceMulγ(p_γ d)
Product of **d** from each PE

Scans (Parallel Prefix)

p_β p_scanAndβ(p_β d)
Bitwise AND of **d** up to this PE

p_β p_scanOrβ(p_β d)
Bitwise OR of **d** up to this PE

p_β p_scanXorβ(p_β d)
Bitwise XOR of **d** up to this PE

p_α p_scanMinα(p_α d)
Minimum of **d** up to this PE

p_α p_scanMaxα(p_α d)
Maximum of **d** up to this PE

p_γ p_scanAddγ(p_γ d)
Sum of **d** up to this PE

p_γ p_scanMulγ(p_γ d)
Product of **d** up to this PE

Voting and Scheduling

int p_first(p_1u f)
Minimum **IPROC** of PE with **f**!=0; **NPROC** if no PE had **f**!=0

int p_count(p_1u f)
Count number of PEs with **f**!=0

int p_quantify(p_1u f)
Quantify number of PEs with **f**!=0; return is 0, 1, 2 (>1), or **NPROC**

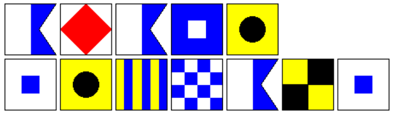
int p_voteCount(int v)
How many PEs voted for our **IPROC**?

p_bar p_vote(int v)
Bit vector with 2^k set *iff* PE*k* **v==IPROC**

int p_matchCountβ(p_β v)
How many PEs had our **v** value?

p_bar p_matchβ(p_β v)
Bit vector with 2^k set *iff* PE*k* had our **v** value

int p_rankα(p_α d)
Position of **d** in sorted order, smallest is 0



AFAPI Signals

The AFAPI aggregate signal system provides replicated shared memory and allows arbitrary user-installed handlers. The sender of a signal is blocked until all processors respond, either by sending a signal or **s_poll()**. Similar concurrent signals can be processed as a group, identified to the signal handler by the **p_bar** argument.

Aggregate Signal Control

void s_ignore(p_bar m)
Default (null) signal handler

int s_install(int s, void(*f)(p_bar m))
Install signal handler **f()**; **s** can be **S_SIGMEM**, **S_SIGANY**, or a previously assigned signal number; return is -1 or signal number

int s_init(void)
Enable signal system, return 0 for no error

void s_exit(void)
Flush and disable signal system

Aggregate Signal Primitives

void s_signal(int s)
Broadcast signal **s**

void s_poll(void)
Poll for pending signal(s)

void s_wait(void)
Barrier synchronization after flushing signals

Replicated Shared Memory

void s_update(void *a, int n)
Shared memory update (write) **n**-byte object at address **a** to all PEs; result is fully coherent RSM

void s_initLock(s_lock *l)
Initialize shared memory lock **l** to **S_INITLOCK**

void s_acquire(s_lock *l)
Acquire shared memory lock **l**

void s_release(s_lock *l)
Release shared memory lock **l**

AFAPI Sample Program

Compute approximate value of π; algorithm from M. J. Quinn, *Parallel Computing Theory And Practice*, McGraw Hill, 1994.

```
#include <stdio.h>
#include "afapi.h"

main(int argc, char **argv)
{
  p_32f width, sum;
  p_32 intervals, i;

  /* check-in with AFAPI */
  if (p_init()) exit(1);

  /* get the number of intervals */
  intervals = atoi(argv[1]);
  width = 1.0 / intervals;

  /* do the local computations */
  sum = 0;
  for (i=IPROC; i<intervals; i+=NPROC) {
    p_32f x = (i + 0.5) * width;
    sum += 4.0 / (1.0 + x * x);
  }

  /* sum local results & scale */
  sum = p_reduceAdd32f(sum) * width;

  /* only the console PE prints */
  if (IPROC == CPROC) {
    printf("Pi is %14.12f\n", sum);
  }

  /* check-out */
  p_exit();
  exit(0);
}
```

AFAPI Compile and Run

gcc *source***.c -o** *exec* -O afapi.a
C compile command

exec args
Run the executable *exec*