Raising the Bar for Using GPUs in Software Packet Processing

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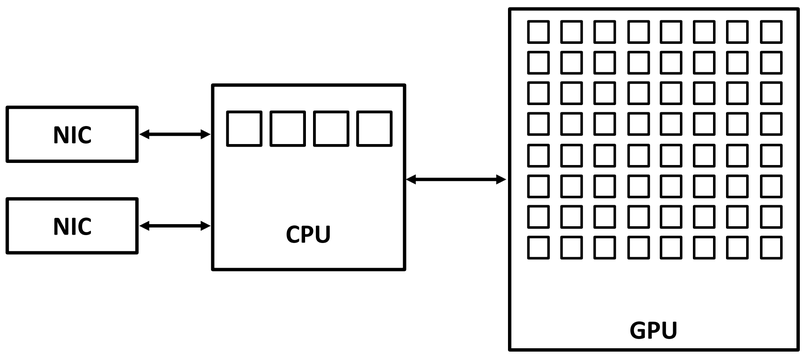
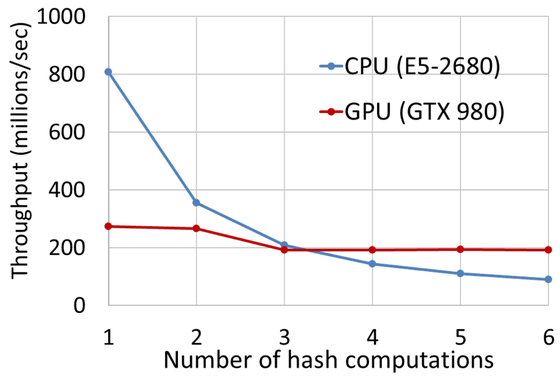
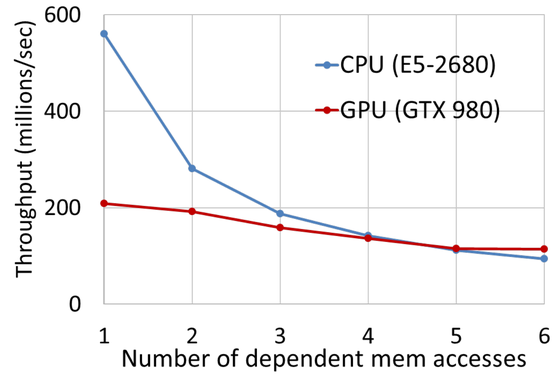
Prior work says GPU acceleration of packet processing is a good idea

GPUs:
- >10x raw compute power
- ~4x higher memory bandwidth



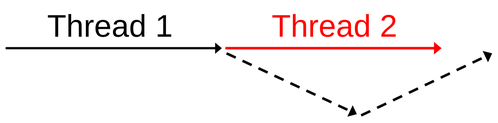
But many packet processing applications are not compute/memory intensive!





Memory latency hiding is the key GPU advantage

GPUs hide memory latency by context switching



Can we hide latency for CPU programs?
- CuckooSwitch [CoNEXT 13]: Group prefetching
- Grappa [U. Washington]: Context switching

Assume programmer exposes parallelism:

```
for(i = 0; i < num_threads; i ++) {
    /*
     * Do something for thread i,
     * independent of other threads.
     */
}
```

G-Opt input code:

```
find(key *K, value *V) {
  int i;
  for(i = 0; i < B; i++) {
    int idx = hash(K[i]);
    _expensive(&table[idx]);
    value *ptr = table[idx].ptr;
    _expensive(ptr);
    V[i] = *ptr;
  }
}
```

G-Opt transform

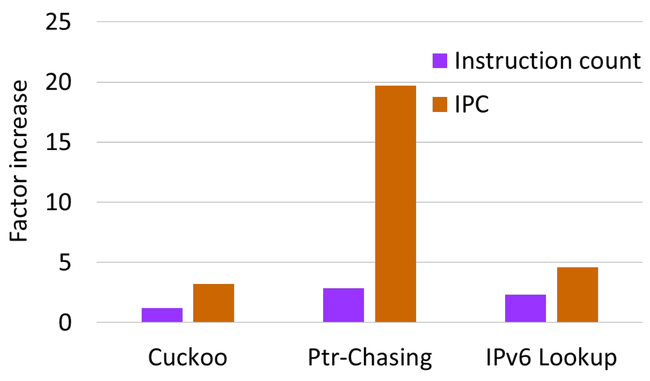
Local variables → Arrays
Annotations → Switching

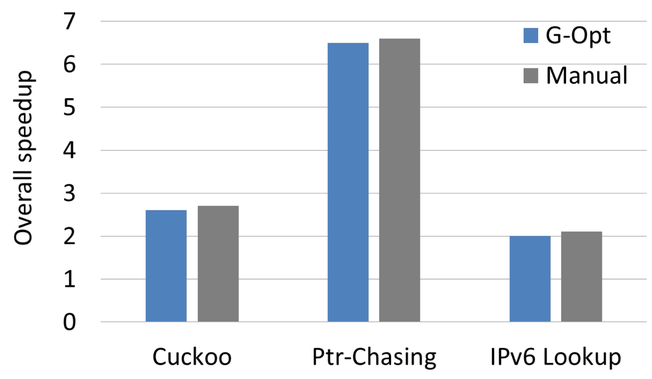
```
// Prefetch, Save label, and Switch element
#define PSS(addr, label) do {
  prefetch(addr); \
  labels[I] = &&label; \
  I = (I + 1) % B; \
  goto *labels[I]; \
} while(0);

find(key *K, value *V) {
  int idx[B];
  value *ptr[B];

  int I = 0, mask = 0;
  void *labels[B] = {label_0};

label_0:
  idx[I] = hash(K[I]);
  PSS(&table[idx[I], label_1);
label_1:
  ptr[I] = table[idx[I]].ptr;
  PSS(ptr[I], label_2);
label_2:
  V[I] = *ptr[I];

end:
  labels[I] = &&end;
  mask = SET_BIT(mask, I);
  if(mask == (1 << B) - 1) return;
  I = (I + 1) % B;
  goto *labels[I];
}
```

Properties:
- Processes batch of elements
- Elements independent of each other
  - Can switch between elements!
- *Annotations for expensive accesses*

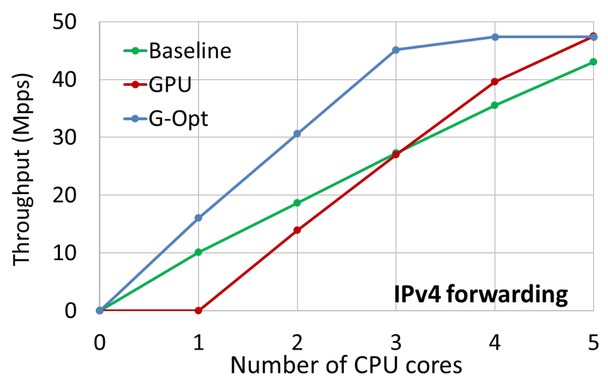
G-Opt makes CPUs more resource efficient than GPUs

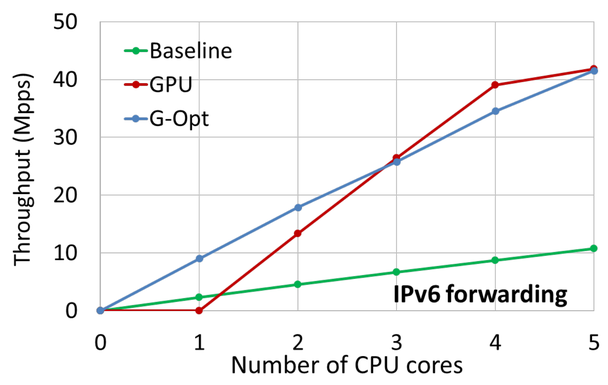
Increases instructions executed, but IPC more

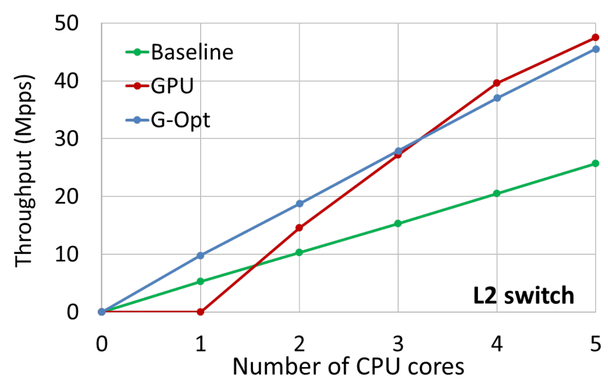


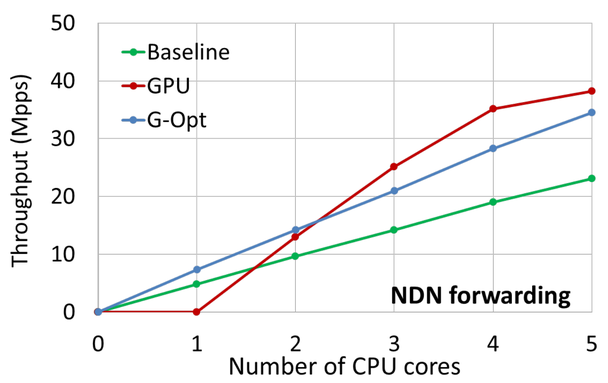


Throughput increase:









Code is online: https://github.com/efficient/gopt

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