A Multi-Objective Integer Linear Program for Memory Assignment in the DSP Domain

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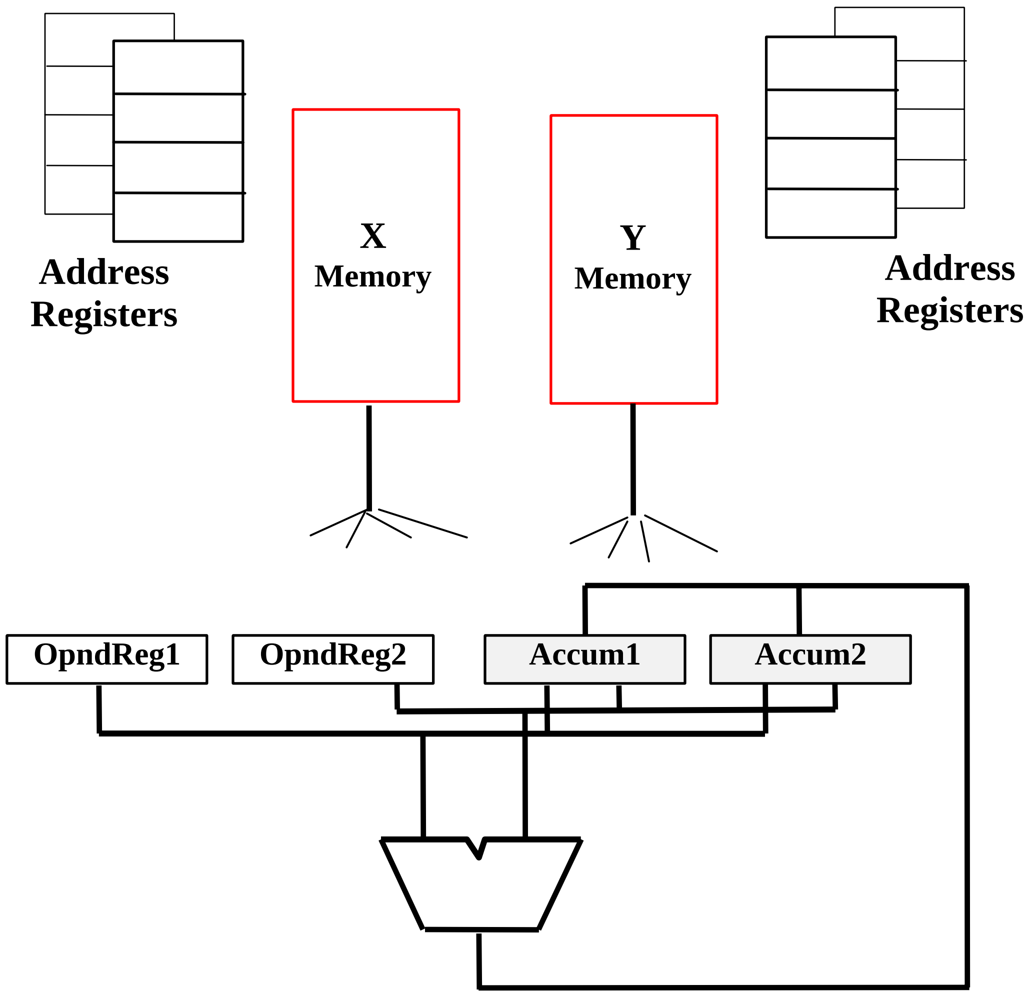
Outline

1. Typical DSP architecture
2. The memory assignment problem for dual memories
3. Constraints and Objective functions
4. Results
5. Closing comments

Typical DSP Architecture

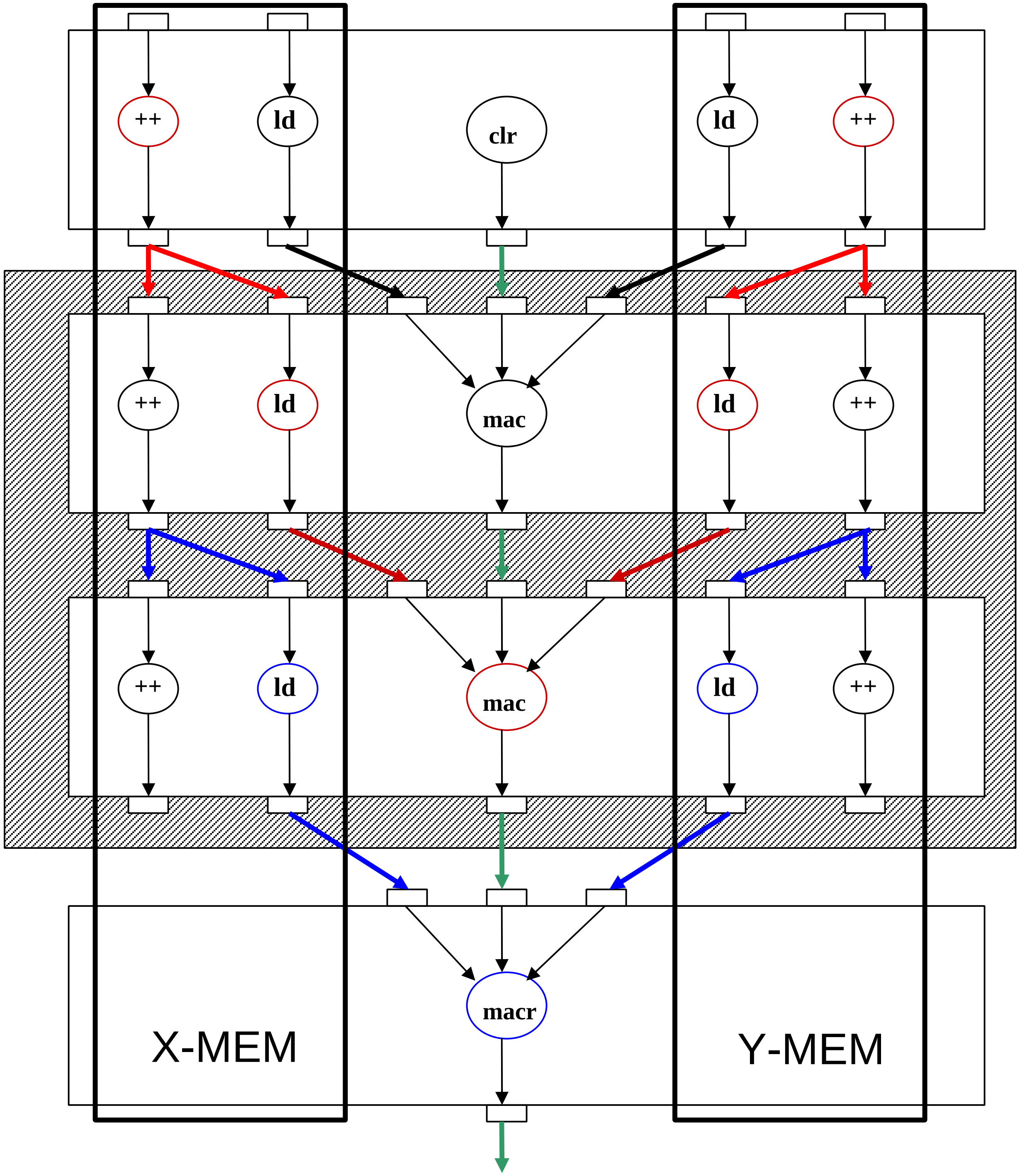


Sample Loop Kernel

```
double FIR_filter(in double A[], in double B[], in int tap) {
    int k;
    double sum=0;

    for(k=0; k< tap; k++)
            sum += A[k] * B[k];
    return sum;
}
```

ALU		X-Memory	Y-Memory	
CLR	A	X:(R0)+, X0	Y:(R4)+,Y0	[1]
REP	#N-1			[2]
MAC	X0,Y0, A	X:(R0)+, X0	Y:(R4)+, Y0	[3]
MACR	X0, Y0, A			[4]



++
ld
clr
ld
++
++
ld
mac
ld
++
++
ld
mac
ld
++
macr
X-MEM
Y-MEM

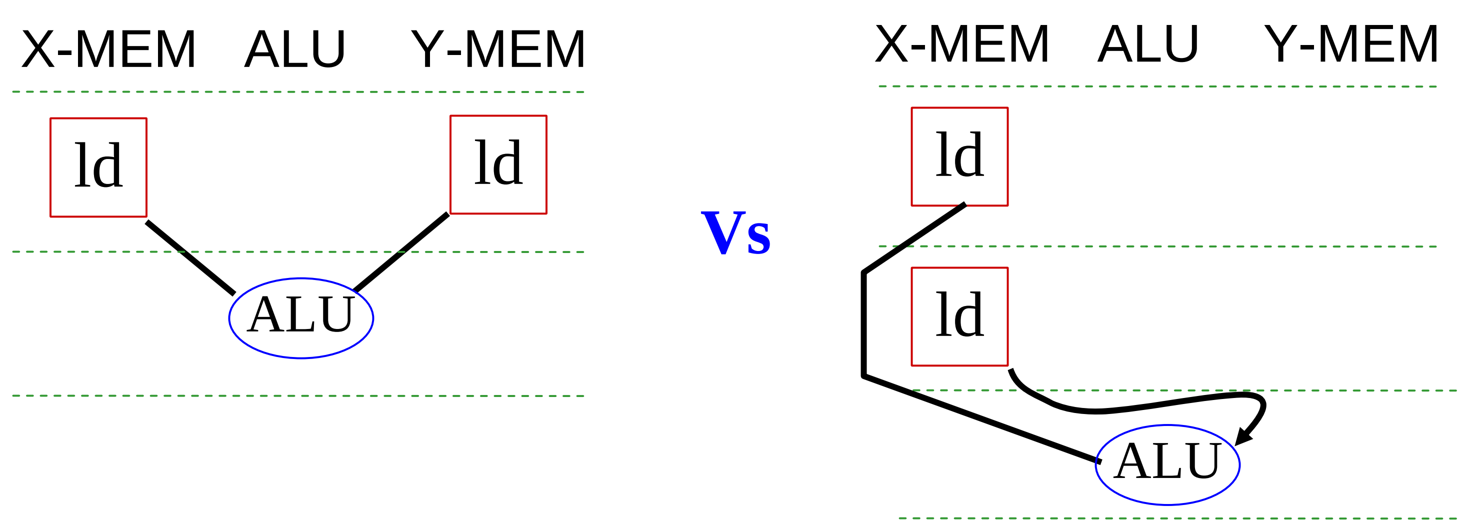
Goal of Data Partitioning

- Goal: To partition the data, prior to scheduling, to create a climate for very parallel, short schedules.

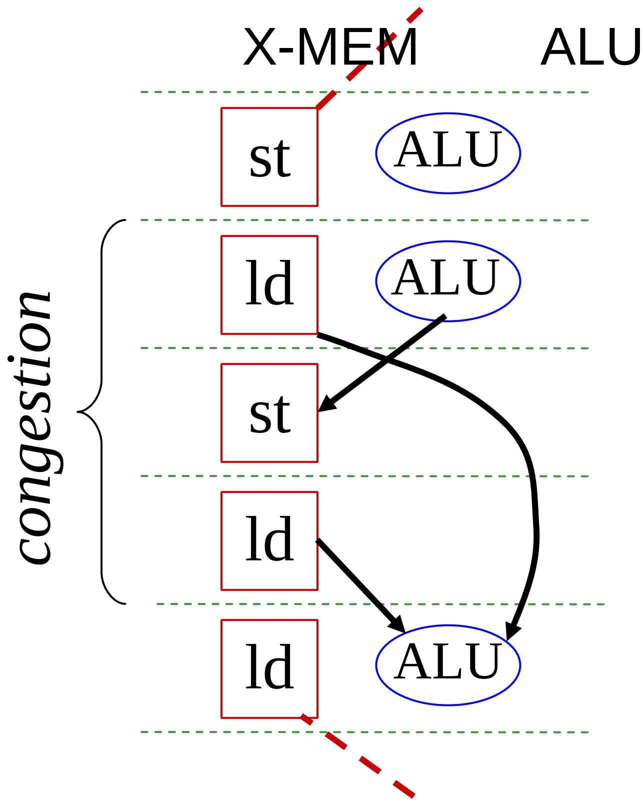
- Problems:
  - Unbalanced Memory Activity
  - Connectivity and non-commutative operations

Load Balancing

- Parallelism in schedules of memory operations promotes the possibility of better schedules.



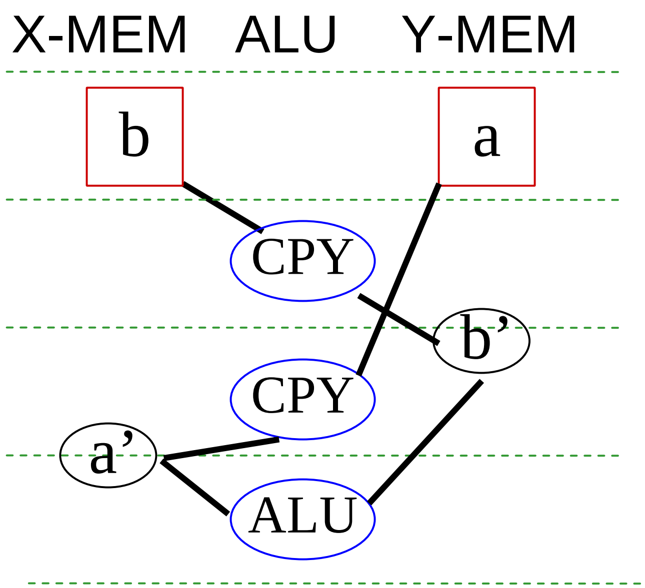
Load Balancing Cont'd



Load balancing can be achieved using:

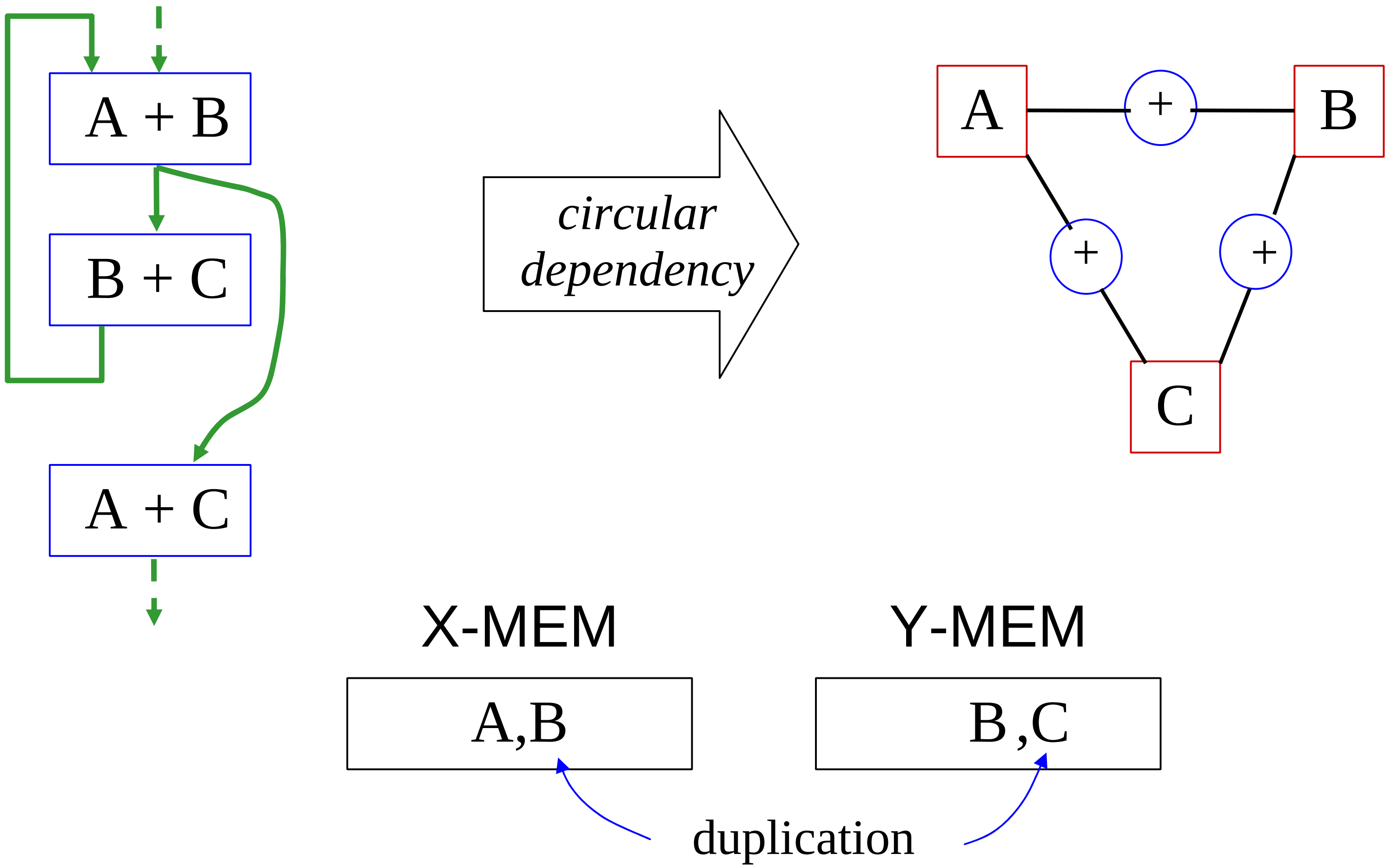
- Objective Function

Register Connectivity



non-commutative

Register Connectivity Cont'd



Remembering the Problem

- Goal: To partition the data, prior to scheduling, to create a climate for very parallel, short schedules.
  - Minimize delays due to values appearing in “wrong” memory
  - While satisfying all *hard* constraints
    - E.g., not exceeding size capacity of either memory

Our Model

- We model the problem as an Integer Linear Program

- The objective function aims to minimize the cost of:
  - Having operands in “wrong” memory – for non-commutative operations
  - Need to update both memories
  - Need to fetch paired operands on separate control steps – for commutative operations

• Block Execution Frequencies used to weight individual objectives can be found through simulation, estimation, experience, etc.

Our Model

- Primary Constraint
  - capacity of either memory cannot be exceeded
- Additional Constraints (Preferences)
  - item *i* must appear in *x* memory
  - item *i* cannot appear in *x* memory
  - items *i* and *j* must have instances in different memories
  - items *i* and *j* must have instances in same memory
  - item *i* cannot be duplicated

Results

- Randomly generate three sets of problems:
  - Set A – 50 variables
  - Set B – 100 variables
  - Set C – 200 variables
- For each set, we varied:
  - # of variables preferred in the left memory (25%-50%)
  - # of variables preferred in the right memory (25%-50%)
  - # of variables that require updating (25%-50%)
  - # of variables that appear in commutative operations (50%-75%)
- Each set contains 16 problem instances

Results

Set	Variables	Solution Times
A	50	0.1s
B	100	1.0 – 2.0 s
C	200	6.0 – 12.0 s

- Lindo solver on Windows 2000, 2.4 GHz P4, 512MB
- Solutions to 5000 variable problems in < 60s

Thanks for Listening