Lecture 12 – Object Oriented Design Example: SpMV

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NERS/ENGR 570 - Methods and Practice of Scientific Computing (F20)

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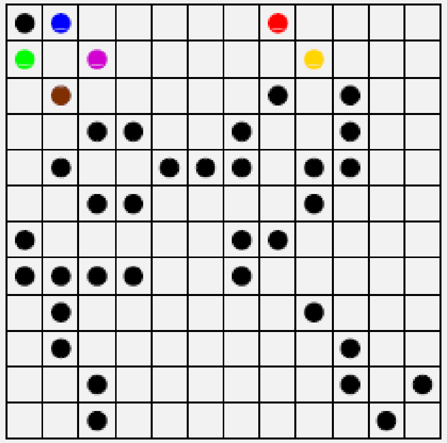
Outline

- Overview of HW 2 (to be assigned after lecture)
- Review of Lab 06
- Class Hierarchy Development
- Matrix State Machine
- Mediator Design Pattern

Sparse Matrix Storage Formats: COOrdinate Storage

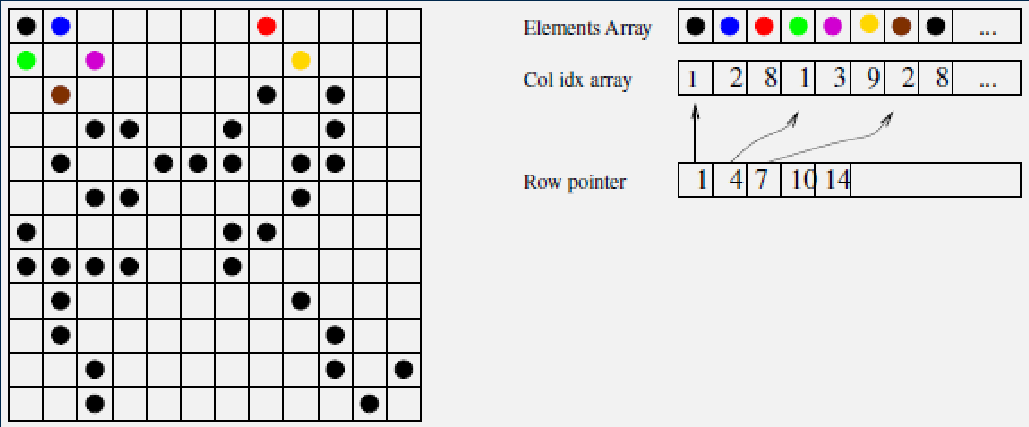


Elements Array	●	●	●	●	●	●	●	●	...
Col idx array	1	2	8	1	3	9	2	8	...
Row idx array	1	1	1	2	2	2	3	3	...

```
do i=1,nz
   ir = ia(i)
   jc = ja(i)
   y(ir) = y(ir) + as(i)*x(jc)
enddo
```

Cost: 5 memory reads, 1 write and 2 flops per iteration.

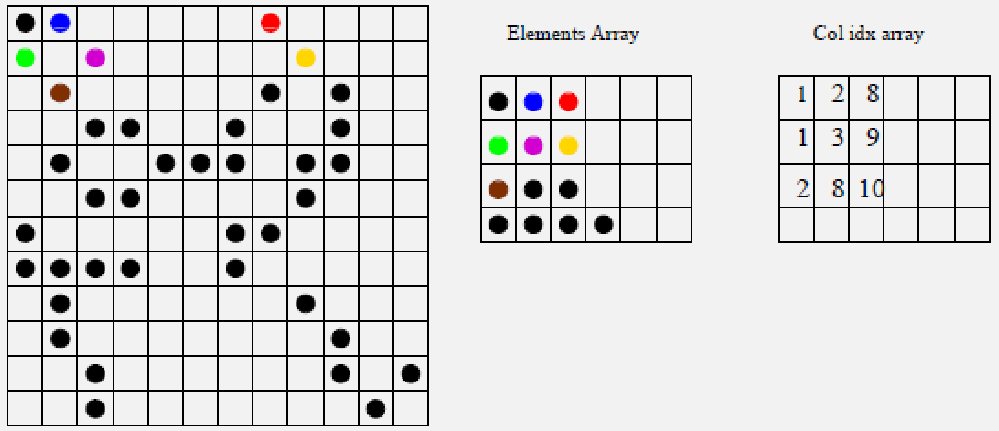
Sparse Matrix Storage Formats: Compressed Sparse Row (CSR) Storage



```
do i=1,m
   do j=ia(i), ia(i+1)-1
      y(i) = y(i) + as(j)*x(ja(j))
   enddo
enddo
```

Cost: 3 memory read and 1 write per outer iteration, 3 memory read and 2 flops per inner iteration.

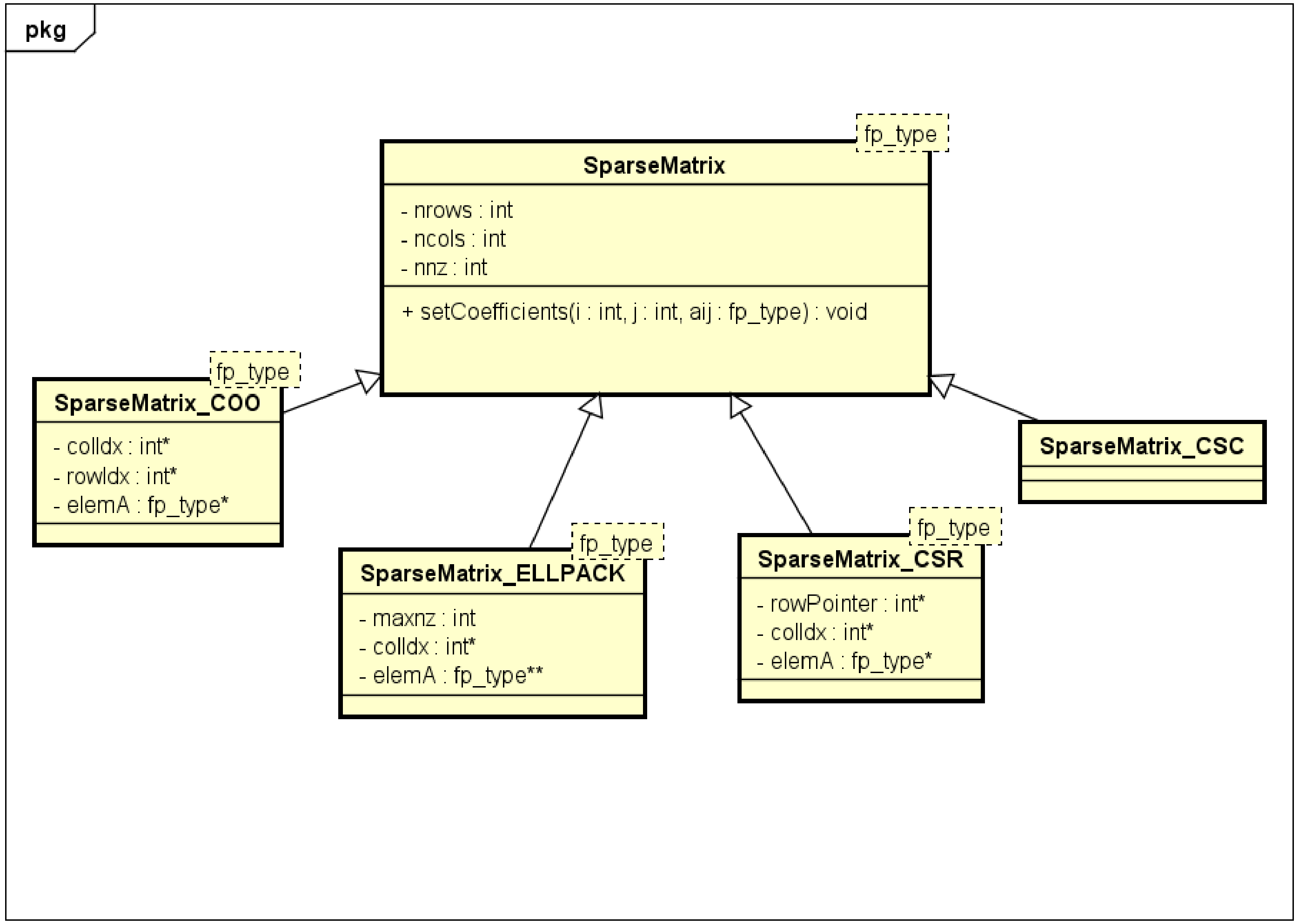
Sparse Matrix Storage Formats: ELLPACK Storage



```
do  i=1,m
   do  j=1,  maxnz
      y(i) = y(i) +  as(i,j)*x(ja(i,j))
   enddo
enddo
```

Cost: 1 memory read and 1 write per outer iteration, 3 memory read and 2 flops per inner iteration (also, regular access pattern).

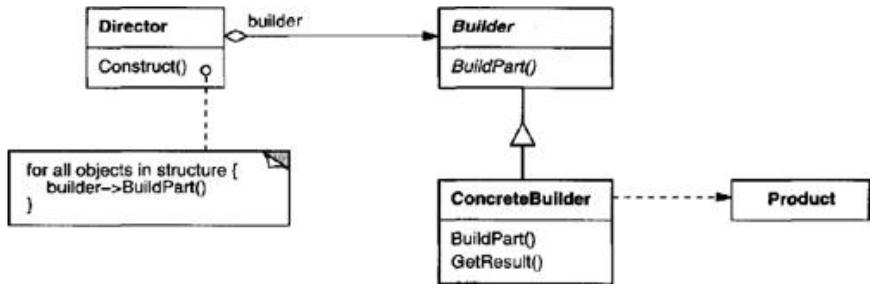
Class Hierarchy

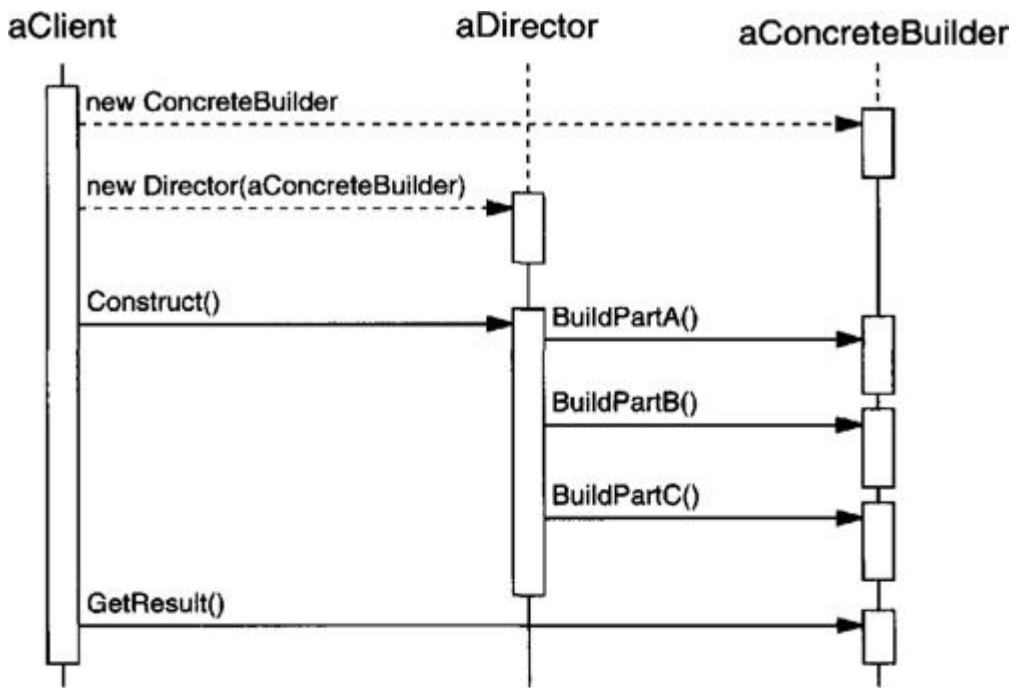


Creational Pattern (Builder)

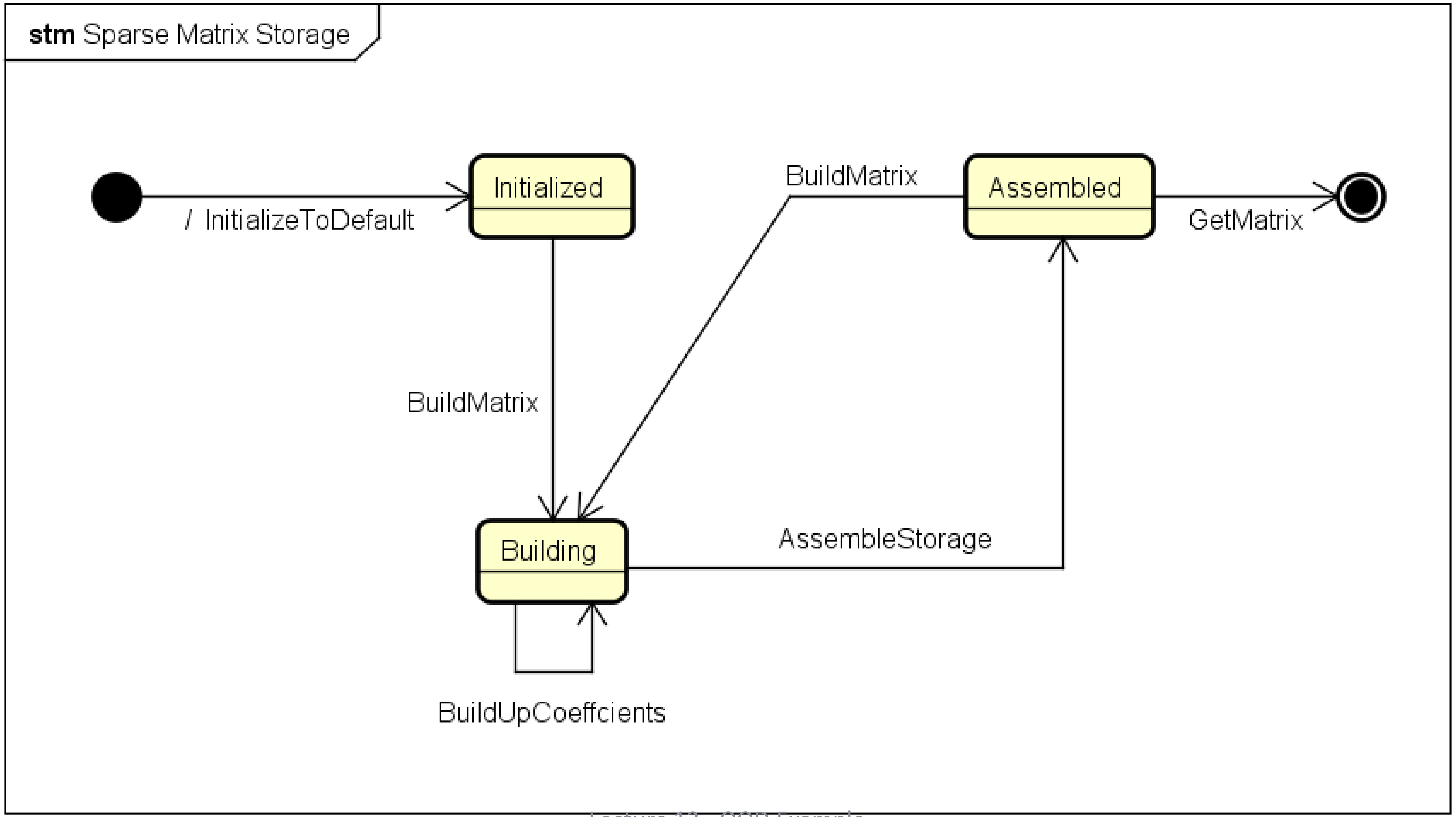
- `InitializeToDefault(`n`)`
  - Create some internal storage and default values
  - e.g. could initialize to identity
- `BuildMatrix()` – Changes state
  - allows values to be set
- `BuildUpCoefficients(`i,j,a_{ij}`)`
  - Assign coefficients to matrix
  - Perhaps overload to allow other formats
    - e.g. COO - `ia(:),ja(:),aa(:)`
  - Store all internally as COO format
- `AssembleStorage()` – Changes state
  - Converts internal representation of data to format suitable for solvers
- `GetMatrix()` – would return the matrix object

Builder Design Pattern



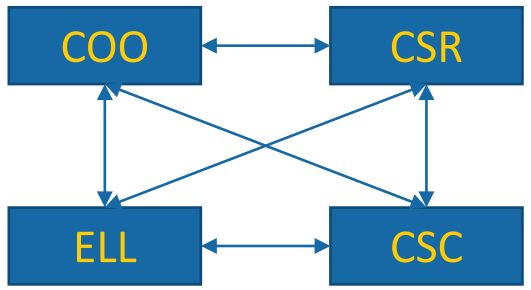


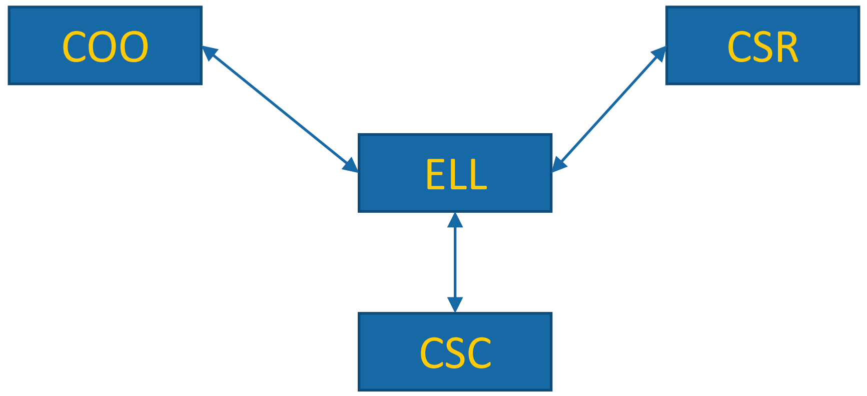
Behavorial Pattern (State)



Behavioral Pattern (Mediator)

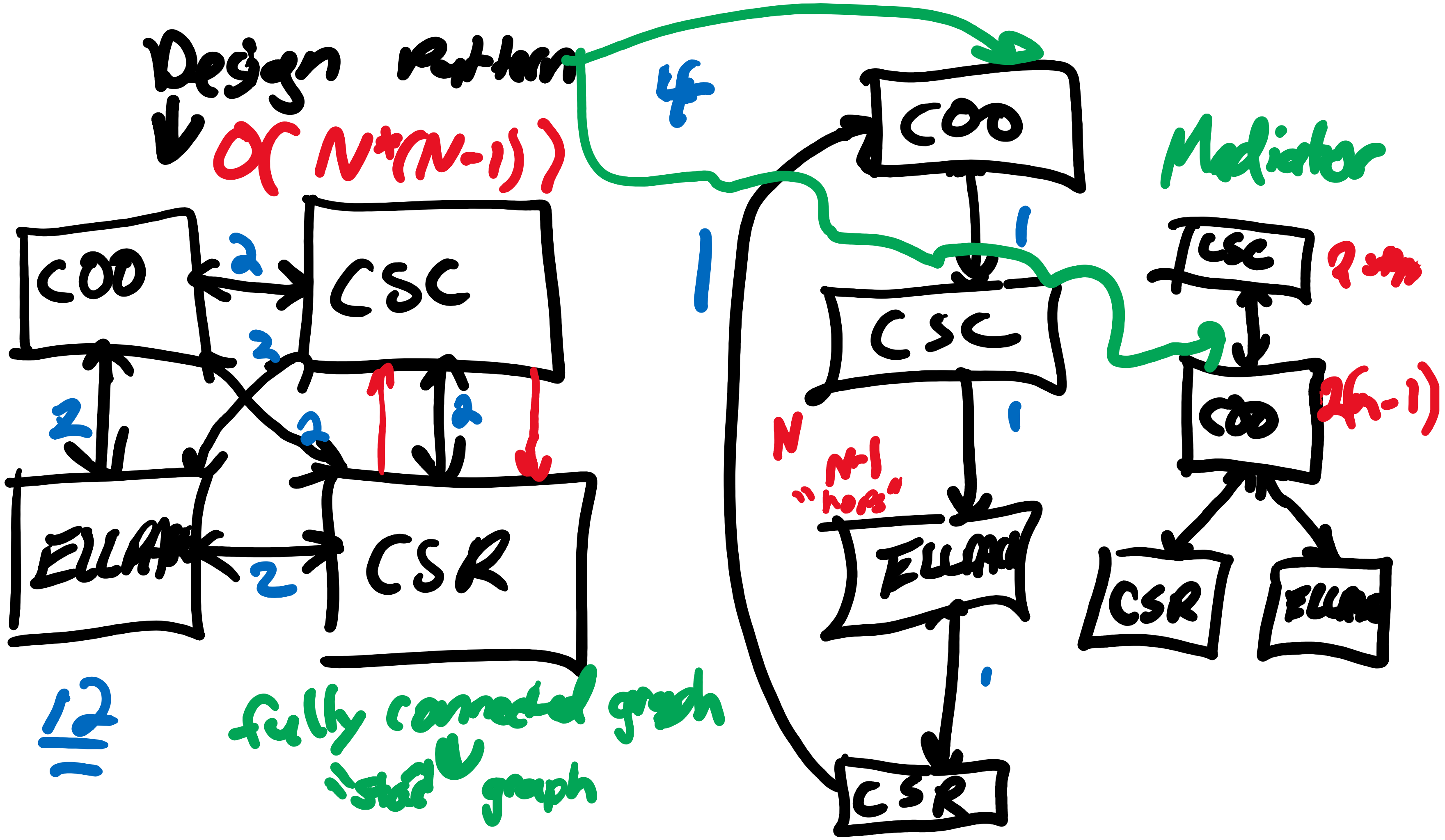
- Support N matrix formats
  - That is N^2 different types of conversions
  - Don’t implement them all!





- Use Mediator!
  - Move from fully connected graph to “star” graph

Notes on Mediator


Design Pattern
O(N*(N-1))
COO
CSC
ELLPACK
CSR
2
12
fully connected graph
"star" graph
4
1
N
N-1
"hops"
Mediator
? steps
2(n-1)