Faculty of Science

PMPH Project

Eliminating duplicate computations

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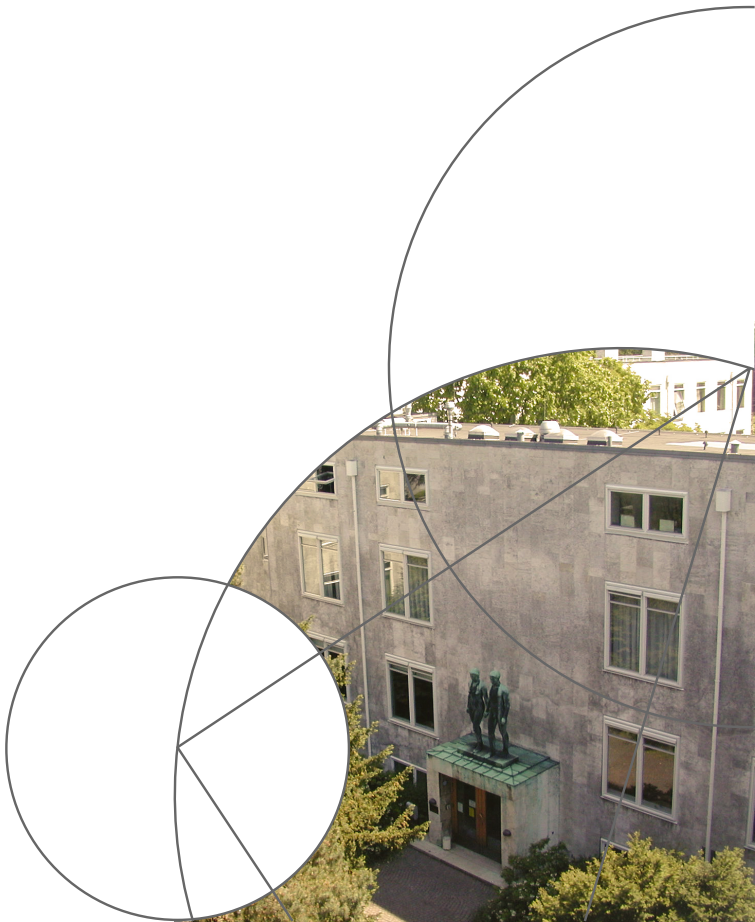

After time loop extraction

- Time loop has been moved out, what do our variables look like?

```
REAL myX[outer][numX];
REAL myY[outer][numY];
REAL myTimeline[outer][numT];
REAL myResult[outer][numX][numY];
REAL myVarX[outer][numX][numY];
REAL myVarY[outer][numX][numY];
REAL myDxx[outer][numX][4];
REAL myDyy[outer][numY][4];
```

- Do we need the `outer` dimension on all of them?

How to determine dependencies

- Need to determine which variables are dependent on the outer dimension, and which that are independent.

How to determine dependencies

- Need to determine which variables are dependent on the outer dimension, and which that are independent.
- To accomplish this: Look at when each variable is read from or written to.

initGrid

```
void initGrid(...) {
  for(unsigned i=0;i<numT;++i)
      myTimeline[o][i] = t*i/(numT-1);
  // ...
  for(unsigned i=0;i<numX;++i)
      myX[o][i] = i*dx - myXindex*dx + s0;
  // ...
  for(unsigned i=0;i<numY;++i)
      myY[o][i] = i*dy - myYindex*dy + logAlpha;
}
```

- Writes to `myTimeline`, `myX`, `myY`.
- Data written is independent of `outer` dimension.
- `myTimeline`, `myX`, `myY` never written to outside of `initGrid`.

initOperator

```
void initOperator(...) {
  // ...
  for(unsigned i=1;i<n-1;i++) {
    dxl       = x[o][i]   - x[o][i-1];
    dxu       = x[o][i+1] - x[o][i];
    Dxx[o][i][0] =  2.0/dxl/(dxl+dxu);
    Dxx[o][i][1] = -2.0*(1.0/dxl + 1.0/dxu)/(dxl+dxu);
    Dxx[o][i][2] =  2.0/dxu/(dxl+dxu);
    Dxx[o][i][3] =  0.0;
  }
  // ...
}
```

- Reads from `myX`, writes to `myDxx`. (Ditto `y`.)
- Data written is independent of `outer` dimension. (If `myX` is.)
- `myDxx` never written to outside of `initGrid`.

setPayoff

```
void setPayoff(...) {
    for (unsigned i=0; i < numX; ++i) {
        REAL payoff = max(myX[o][i]-strike, (REAL)0.0);
        for (unsigned j=0; j < numY; ++j)
            myResult[o][i][j] = payoff;
    }
}
```

- Reads from `myX`, writes to `myResult`.
- Data written is dependent on `outer` dimension.
  - `strike` is a function of `o`!

updateParams

```
void updateParams(...) {
  for (unsigned i=0; i < numX; ++i)
    for (unsigned j=0; j < numY; ++j) {
      myVarX[o][i][j] = f(myX[o][i], myY[o][j], myTimeline↩
          [o][g]);
      myVarY[o][i][j] = g(myX[o][i], myY[o][j], myTimeline↩
          [o][g]);
    }
}
```

- Reads from `myX`, `myY`, `myTimeline`, writes to `myVarX`, `myVarY`.
- Data written is not dependent on `outer` dimension.[1]
- `myVarX` and `myVarY` never written to outside of `initGrid`.

[1] The variables used are independent of it, per our previous slides.

`rollback`

- Partitioned into four logical parts: Explicit X, explicit Y, implicit X, implicit Y.
- We analyse each of these separately.

rollback - Explicit X

```
REAL dtInv = 1.0/(myTimeline[o][g+1]-myTimeline[o][g]);
// ...
for(i=0;i<numX;i++) {
  for(j=0;j<numY;j++) {
    u[j][i] = dtInv*myResult[o][i][j];
    if(i > 0) {
      u[j][i] += f(myVarX[o][i][j],myDxx[o][i][0],myResult[o][i-1][j]);
    }
    u[j][i] += g(myVarX[o][i][j],myDxx[o][i][1],myResult[o][i][j]);
    if(i < numX-1) {
      u[j][i] += h(myVarX[o][i][j],myDxx[o][i][2],myResult[o][i+1][j]);
    }
  }
}
```

- Reads from a number of globs, but doesn't write to any!

rollback - Explicit Y

```
for(j=0;j<numY;j++) {
  for(i=0;i<numX;i++) {
    v[i][j] = 0.0;
    if(j > 0) {
      v[i][j] += f(myVarY[o][i][j],myDyy[o][j][0],myResult[o][i][j-1]);
    }
    v[i][j] += g(myVarY[o][i][j],myDyy[o][j][1],myResult[o][i][j]);
    if(j < numY-1) {
      v[i][j] += h(myVarY[o][i][j],myDyy[o][j][2],myResult[o][i][j+1]);
    }
    u[j][i] += v[i][j];
  }
}
```

- Reads from a number of globs, but doesn't write to any!

rollback - implicit X

```
REAL dtInv = 1.0/(myTimeline[o][g+1]-myTimeline[o][g]);
// ...
for(j=0;j<numY;j++) {
  for(i=0;i<numX;i++) {
    a[i] =          - 0.5*(0.5*myVarX[o][i][j]*myDxx[o][i][0]);
    b[i] = dtInv - 0.5*(0.5*myVarX[o][i][j]*myDxx[o][i][1]);
    c[i] =          - 0.5*(0.5*myVarX[o][i][j]*myDxx[o][i][2]);
  }
  tridag(a,b,c,u[j],numX,u[j],yy);
}
```

- Reads from a number of globs, but doesn't write to any!

rollback - implicit Y

```
REAL dtInv = 1.0/(myTimeline[o][g+1]-myTimeline[o][g]);
// ...
for(i=0;i<numX;i++) {
  for(j=0;j<numY;j++) {
    a[j] =          - 0.5*(0.5*myVarY[o][i][j]*myDyy[o][j][0]);
    b[j] = dtInv - 0.5*(0.5*myVarY[o][i][j]*myDyy[o][j][1]);
    c[j] =          - 0.5*(0.5*myVarY[o][i][j]*myDyy[o][j][2]);
    y[j] = dtInv*u[j][i] - 0.5*v[i][j];
  }
  tridag(a,b,c,y,numY,globs.myResult[i],yy);
}
```

- Reads from a number of globs, writes to myResult.

Overview of dependencies

- We can create a table of these dependencies:

Function	myX	myY	myTimeline	myResult	myVarX	myVarY	myDxx	myDyy
initGrid	W	W	W					
initOperator, x	R						W	
initOperator, y		R						W
setPayoff	R			W				
updateParams	R	R	R		W	W		
rollback, explicit x				R	R		R	
rollback, explicit y				R		R		R
rollback, implicit x					R		R	
rollback, implicit y				W		R		R

- Only `myResult` actually needs to be computed separately for each outer iteration.

After reduction of duplicate computations

- After this reduction, our variables look as follows:

```
REAL myX[numX];
REAL myY[numY];
REAL myTimeline[numT];
REAL myResult[outer][numX][numY];
REAL myVarX[numX][numY];
REAL myVarY[numX][numY];
REAL myDxx[numX][4];
REAL myDyy[numY][4];
```