Assignment 1 - OpenMP

- **Use OpenMP to parallelize the deqn code**
  - **The overall objective is to achieve good speedup by inserting OpenMP directives in the deqn code**
    - Speedup is the ratio of the execution time of the sequential version of a program to the execution time of the parallel version of the program
- **You also need to**
  - **benchmark the runtime of each relevant loop and the runtime of the whole parallel program against the number of threads**
  - **benchmark the overhead of OpenMP**

Assignment 1 - OpenMP

- **Write a report**
  - Explain in detail what you did with the sequential code
  - benchmark the runtime of each relevant loop and the runtime of the whole parallel program against the number of threads; present the runtimes in graph or table; analyze the results
  - Discuss the iteration scheduling in your program
  - Analyze the overhead of OpenMP
  - Presentation skills, spelling, punctuation and grammar
  - Up to four A4 pages

Submission

- **Put all the codes and the report (pdf file) in a zip package and submit the zip package through Tabula**

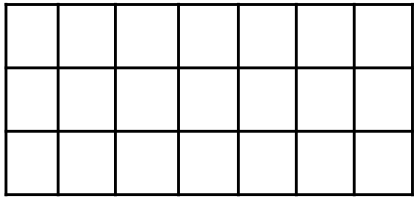
- **Deadline: 12 noon, Feb 9th, 2021**

deqn

- Model the transfer of heat through a material
- Expressed as a partial differential equation, where *u* is the temperature, which is the function over coordinates *x* and *y*, and time t

$$\frac{\partial u}{\partial t} - \alpha\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) = 0$$

- Use the numerical method to solve the equation, i.e, obtain the values of *u* at coordinates (x, y) and at time points t
  - Discretize the space and the time



Discretize the space

Discretize the time

deqn

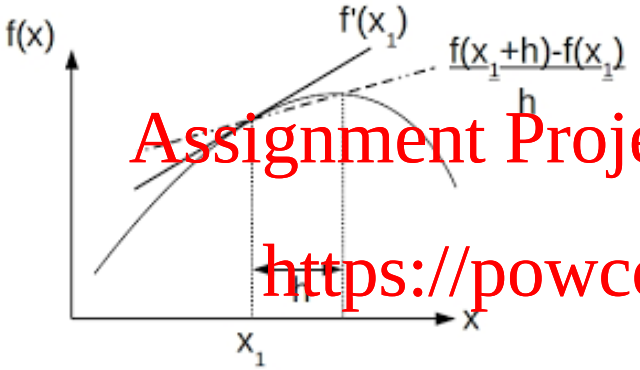
- Model the transfer of heat through a material
- Expressed as a partial differential equation, where *u* is the temperature , *x* and *y* are coordinates

$$\frac{\partial u}{\partial t} - \alpha\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) = 0$$

- Use the numerical method to solve the equation, i.e, obtain the values of *u* at the coordinates (x, y) and at the time point t
  - Discretize the space and the time
  - Convert partial differential equation to linear equation

Convert partial differential equation to linear equation

$$\frac{\partial u}{\partial t} - \alpha\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) = 0$$



$$\frac{\partial u}{\partial t} = \frac{u^{t+k}_{x,y} - u^{t}_{x,y}}{k}$$

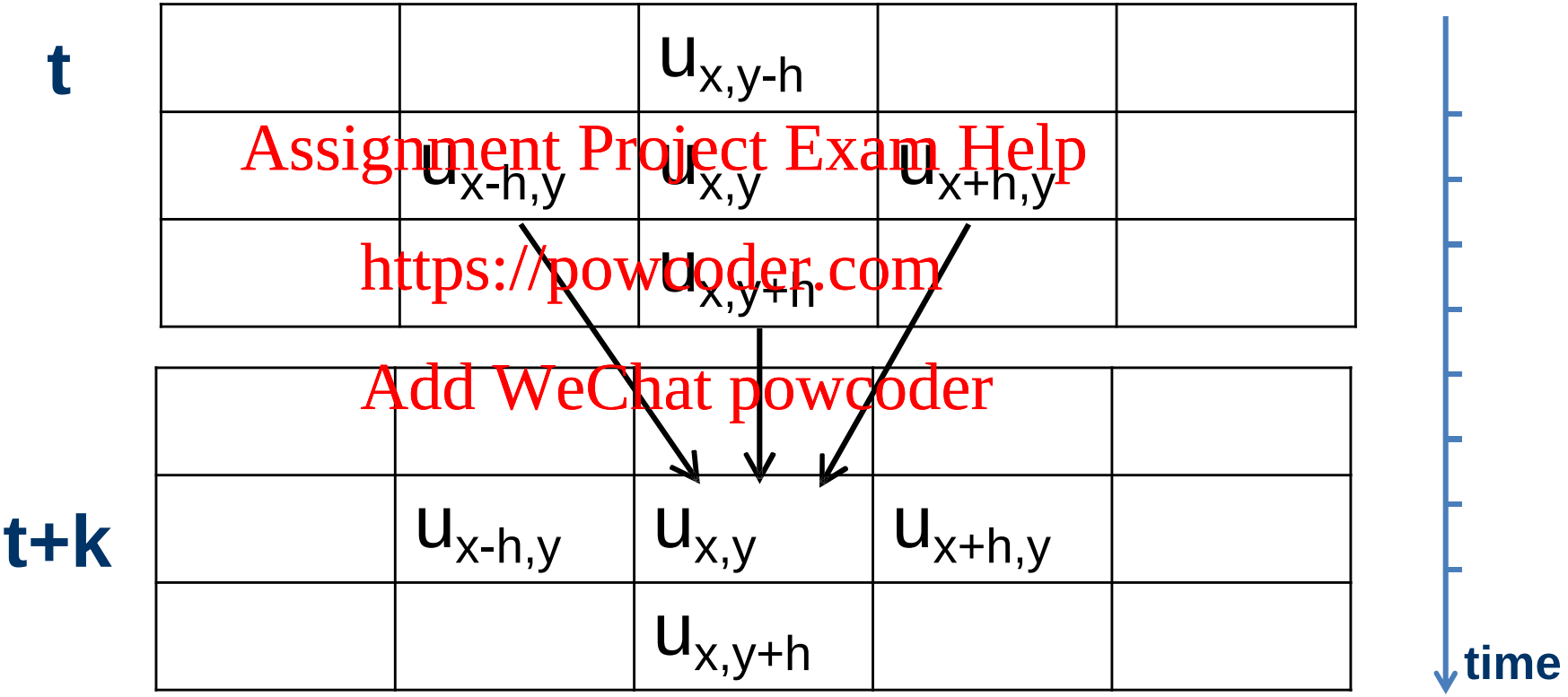
$$\frac{\partial^2 u}{\partial x^2} = \frac{u^{t}_{x+h,y} - 2u^{t}_{x,y} + u^{t}_{x-h,y}}{h^2} \qquad \frac{\partial^2 u}{\partial y^2} = \frac{u^{t}_{x,y+h} - 2u^{t}_{x,y} + u^{t}_{x,y-h}}{h^2}$$

$$\frac{\partial u}{\partial t} - \alpha\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right) = 0$$

$$u^{t+k}_{x,y} = ru^{t}_{x+h_x,y} + ru^{t}_{x-h_x,y} + r'u^{t}_{x,y+h_y} + r'u^{t}_{x,y-h_y} + (1 - 2r - 2r')u^{t}_{x,y}$$

Data Dependency

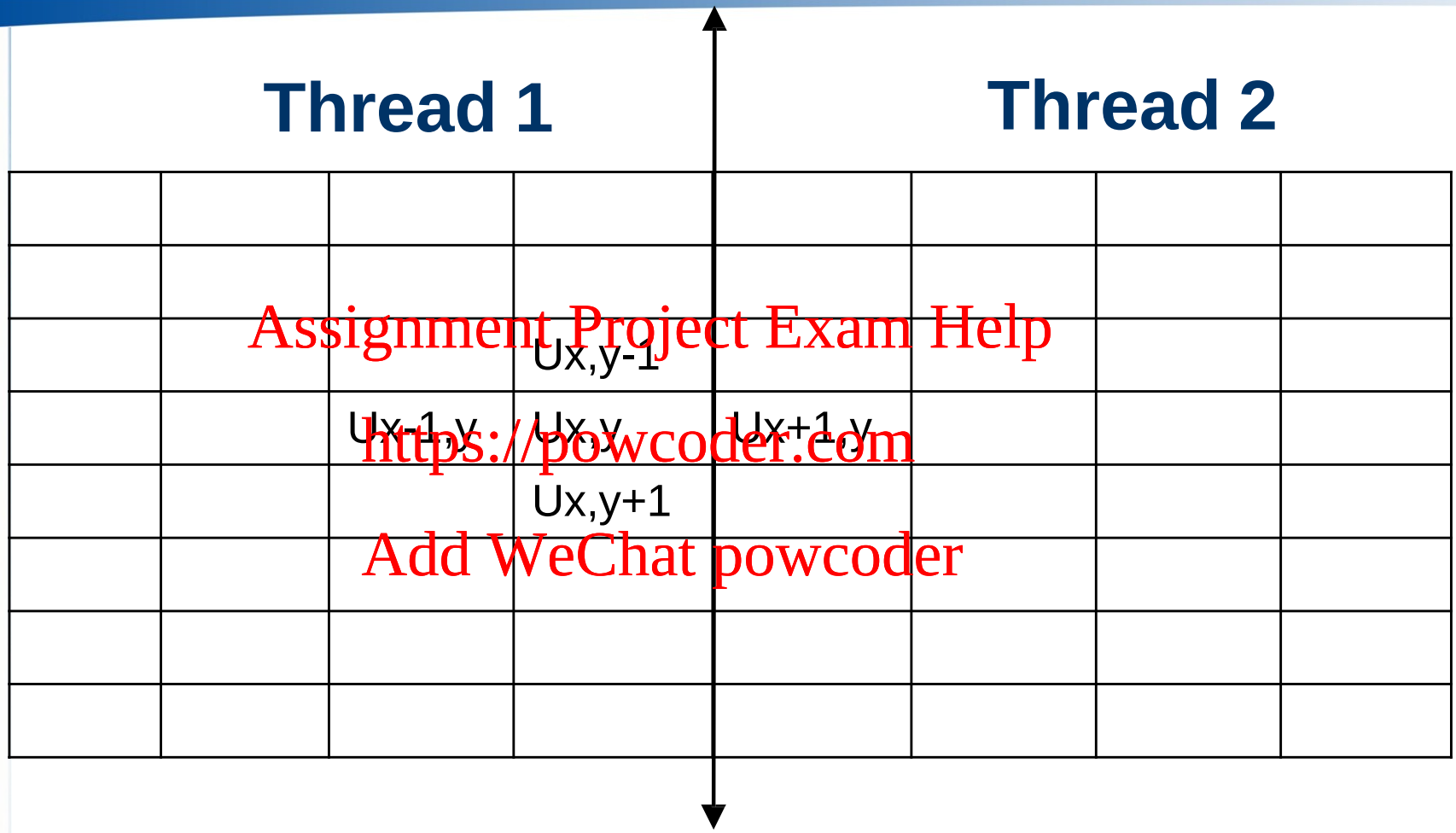
$$u_{x,y}^{t+k} = ru_{x+h_x,y}^{t} + ru_{x-h_x,y}^{t} + r'u_{x,y+h_y}^{t} + r'u_{x,y-h_y}^{t} + (1-2r-2r')u_{x,y}^{t}$$



Given the initial temperature of the material, we can calculate the temperature of the material at any time point and space location

Question: How to parallelize the computation?

Parallelism



- Each thread calculates the temperature at any time and at its local space in parallel
- Thread communication