Training day structure

- **General information on the Techila system (10-11)**
  - Operating principle of Techila, available features, terminology, concept of gridification, general things to consider
  - Quick introduction of the Techila Grid Management Kit and Techila Web Interface

- **Techila with Matlab (11-12)**
  - Short introduction on the main interfaces; Peach and GridFor
  - Preparation, testing & hands on labs using MATLAB

- **Lunch (12-13)**

- **Techila with R (13-14)**
  - Short introduction on the R Peach interface and of the required packages
  - Preparation, testing & hands-on labs using R

- **Techila with Python and Java (14-15)**
  - Short intros on the Python and Java Peach syntaxes and required preparation steps
  - Hands-on labs
Distributed Computing Problems

- **Parallel Problems**
  - Jobs depend on each other’s states
  - Communication between jobs
  - For example fluid dynamics or finite element models
  - Usually not suitable for Grid-type environment

- **Embarrassingly Parallel Problems**
  - Jobs are totally independent
  - No communication between jobs
  - For example Monte Carlo, MCMC
    - Suitable for distributed computing → Techila Grid
Computational Models

Parallel Computing
- Parallel Problems

Distributed Computing
- Embarrassingly Parallel Problems
  - Techila Grid
Roles

- **Worker**
  - Workstations, laptops, clusters
  - Windows, Linux, Mac OS X
- **Server**
  - Management
  - Security
- **End-User**
  - Researcher
  - Using his/her own workstation

- Sends computational data to the server
- Receives final results
- Manages computation resources
- Distributes computations
- Stores results
- Provides computing power

End-User Tier
End-user
Management Tier
Server
Computation Tier
Worker
Worker
Worker
Authentication

- Authentication with End-User specific Keys (typically username.jks)
  - All the connections are secured using the End-User Key
  - All the bundles are signed with the End-User Key
  - Stored in a password protected keystore
  - Handle with care → do not store in an insecure location
Techila Grid Management Kit

- **Enables access to the Techila environment**
  - Latest version available at the Techila Extranet and http://www.techila.fi/TechilaGMK.zip
  - Techila Extranet located at: www.techila.fi/extranet/
    - Requires registration

- **Contains:**
  - Techila Grid Getting Started document
  - Examples for various programming languages, including MATLAB and R
  - Examples on how to distribute binaries by using the Command Line Interface (CLI)
  - End-User Guides for MATLAB, R and the CLI with walkthroughs of the examples

- **Easy to update:**
  - Simply download the new version and extract over the old installation
  - Configuration settings in the grid_settings.ini file will not be overwritten
Configuring the grid_settings.ini file

- Configuration needed to define the address of the Techila Server and location of the keystore file

- Steps:
  1. Download and extract the TechilaGMK.zip on your computer
  2. Navigate to the 'gmk' directory in the Techila Grid Management Kit
  3. Rename the file 'grid_settings.ini.template' to 'grid_settings.ini'
  4. Open the 'grid_settings.ini' with a text editor
  5. Modify the following parameters
     - hostname = techila.mathstat.helsinki.fi
     - alias = <The alias of your End-User Key>
     - keystore = <Location of the keystore (.jks) file>
  6. Save changes
Techila Web Interface

- Information on the Techila environment
- Contains information on your Projects
- Can be used for stopping, removing and restarting Projects
- Provides easy access to error messages
- Login required
- Status page located at:
  
  **https://techila.mathstat.helsinki.fi/status.php**
Terminology

- **Bundles**
  - Created automatically when creating a Project
  - Containers for data, binaries, libraries
    - Used to transfer all necessary components to Workers
  - Dependencies on other bundles
    - All required Bundles are transferred automatically
  - Security
    - Only signed Bundles allowed in the Techila system
  - Life Cycle Management
    - Expiration times can be defined to automatically remove old, unused Bundles
  - Deployed from Server to Workers on-demand
Terminology

- **Project**
  - Computational problem
  - Container for Jobs
  - Control parameters for the execution

- **Jobs**
  - Smallest units in the computational problem
  - Partial problems
  - Deployed and solved on the Workers
Process Flow

**Local Activity - Visible to the End-User**
- End-User
  - Computational Data
- End-User
  - Final Results

**Grid Activity - Hidden from the End-User**
- Server
  - Project
    - Bundles
- Server
  - Project
    - Results
- Assign jobs
  - Transfer bundles
- Worker
  - Required Bundles
- Worker
  - Required Bundles
- Aggregate results
  - Transfer partial results
- End-User
  - Transfer results
- Project completed
  - Transfer bundles
- Create project
  - Create and transfer bundles
- End-User
  - Computational Data
Gridification

Locally executable loop structure

Start

Counter + 1

Code

Counter > 1000

NO

YES

Complete

Gridified loop structure

Start

Counter + 0

Counter + 1

... Counter + 1000

Code

Code

Complete

Time
Gridification

- Locate the demanding parts of the code
  - Profiling (MATLAB profiler)
    - Information with "doc profiler" in MATLAB
  - Timing (debug printouts with timestamps)

- Divide the code into two parts
  - Demanding part (individually executable) → Worker Code
  - Other code → Local Control Code
  - Find out all the parameters needed to be delivered to and from demanding part

- Make sure everything works
  - Call "Worker Code" from "the Local Control Code" with the necessary parameters

- Gridify
  - Change the call to Grid call → PEACH()
Before Running the code in Grid

- Make sure the code works locally
- Check the memory consumption
  - The workers are usually workstations without large memory space
- Check the IO-load vs CPU-load
  - Computation should be more CPU-intensive than data-intensive
- Check the size of the input data and output data
  - The network latency to transfer the data may reduce performance
- Check the length of a single job
  - Extremely short jobs (less than few seconds) are not effective because of network latency
  - Long jobs may get interrupted (and restarted) because of unstable environment (reboots)
    → Snapshot support!!!
Peach

- **Peach**
  - Finds prerequisites for function
  - If necessary, compiles the function with prerequisites
  - Deploys the executable program to the Grid
  - Executes the program on Workers with given parameters
  - Additionally transfers datafiles to the Workers

- **Peachvector**
  - Tells the number of the jobs to be created into project
  - Gives job-specific input data for the project ("<param>")

```
peach(funcname, params, files, peachvector)
```

<table>
<thead>
<tr>
<th>Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Files</td>
</tr>
<tr>
<td>Number of jobs</td>
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Peach

Original Code

```matlab
... for x=1:length(S0)
    for y=1:length(sigma0)
        price(y,x) = asian(S0(x),sigma0(y)^2,M,nn,r,N,rho,kappa,psi,E,T);
    end
end
... function [price] = asian(S0,v0,M,nn,r,N,rho,kappa,psi,E,T)
...```

Peach Control Code

```matlab
... price = peach('asian', {S0, sigma0.^2, M, nn, r, N, rho, kappa, psi, E, T, '<param>'}, 1:length(S0)*length(sigma0)); price = cell2mat(reshape(price,length(sigma0),length(S0)));
...```

Peach Worker Code

```matlab
function [price] = asian(Sx,vx,M,nn,r,N,rho,kappa,psi,E,T,jobidx)
[j, i] = ind2sub([length(vx), length(Sx)], jobidx);
S0 = Sx(i);
v0 = vx(j);
...```
Peach

- Single command interface to Techila Grid
  - Simplest form: `peach(funcname, params, peachvector)`

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End-User

- End-User calls `Peach()`
- End-User Receives Results from Peach

PEACH Internal Process Flow – Hidden from the End-User

- Create Executor Bundle
- Create Data Bundle
- Create Job Input Bundle
- Create Parameter Bundle
- Create Project using Peach Parameters
- Unload
- Cleanup
- Load Results
- Download Results

Grid Environment

- Workers
- Compute

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GridFor

- Currently available for MATLAB

**Original Code**

```matlab
... for x=1:length(S0)
    for y=1:length(sigma0)
        price(y,x) = asian_montecarlo(S0(x),sigma0(y)^2,M,nn,r,N,rho,kappa,psi,E,T);
    end
end
... 
function [price] = asian_montecarlo(S0,v0,M,nn,r,N,rho,kappa,psi,E,T)
...```

**GridFor Code**

```matlab
... gridfor x=1:length(S0)
    gridfor y=1:length(sigma0)
        price(y,x) = asian_montecarlo(S0(x),sigma0(y)^2,M,nn,r,N,rho,kappa,psi,E,T);
    gridend
gridend
... function [price] = asian_montecarlo(S0,v0,M,nn,r,N,rho,kappa,psi,E,T)
...```
Features:

- Can be used to improve efficiency and implement more complex distributions

Features include:

- Snapshots
- Streaming
- Callback functions
- Job-specific input files
- Distributing precompiled binaries
- Detached Projects
- ...
Features: Snapshots

- **Saving project state**
  - Requires support in computation code
    - To save the state
    - To resume from the saved state

- **Saves time in long runs**
  - Resuming after reboot
  - Resuming on another Worker
  - Optimizing → transfer to faster Worker
Features: Snapshots

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  - Requires support in computation code
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**Worker Code**

```matlab
% Without snapshot
result=0
for iter=1:10000
    result=comp_intensive_function(result)
end

% With snapshot
iter=1;result=0;
% Override init values if resuming from a snapshot
loadSnapshot()
for iter=iter:10000
    result=comp_intensive_function(result)
end
saveSnapshot('result','iter') % Save intermediate results
```

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Features: Streaming

- Transfer results from the Grid as soon as they are available
  - Enables post-processing job results before the project is completed
  - Saves time when the results are large
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  - Enables post-processing job results before the project is completed
  - Saves time when the results are large
Features: Callback

- Easy way to post-process results
  - Each job result is delivered to the callback function
  - Results from the callback function are optionally returned from peach()

- For example:
  - To plot the results part-by-part
  - To strip parts of the result to files and return other parts from peach()
  - To save memory
  - To manage large result files
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- For example:
  - To plot the results part-by-part
  - To strip parts of the result to files and return other parts from peach()
  - To save memory
  - To manage large result files

```matlab
% Without callback
function result = run_example()
    result = peach('funcname',{},1:jobs,)
end

% With callback
function result = run_example()
    result = peach('funcname',{},1:jobs, ...
                   'CallbackMethod', @callback) % Name of CB function
end

function result = callback(result_file) % CB function
    result=post_process(result_file)
end
```
Features: Job Input Files

- Enables job-specific data files
  - Other bundles are deployed to each participating Worker
  - Job Input Bundle is transferred only to the server
  - Individual files from the Bundle are deployed to the Workers

- Saves memory
  - Only the part of the data needed by the job is in the inputdata

- Saves time and network
  - Only the part needed by the job is transferred from the server
Features: Precompiled binaries

- Using MATLAB/Perl/Command Line Interface as the front-end
  - Compute with precompiled binary (Fortran, C/C++, etc.)
  - Optionally post-process with MATLAB/Perl
  - Easy way to execute code written in languages not having peach() (yet)
  - Possible to execute the computation on multiple platforms
    - Requires precompiled binary for each of the platforms
Features: Project Detaching

- No need to wait for the projects
  - Start the long project from laptop, turn off the laptop and have a nice weekend
  - Fetch the results on Monday

Normal Convention

Detached Project
Low-Level Interface

- Peach works in most of the cases
  - But sometimes it may not be enough
- Possible to use low level interface
  - To create bundles
  - To handle bundle requirement trees
  - To handle bundle parameters
  - To create projects
  - To handle project parameters
  - To create individual jobs into projects
  - To monitor the projects
  - To download the results
  - To…