City University of Hong Kong

Department of Computer Science

**CS3504-IT professional placement**

# Placement Report


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# 1 Objectives of Placement

IT professional placement aims to provide students with the opportunity to appreciate a real IT oriented working environment; to relate concepts and principles of different subject areas learned to the real environment; to enhance students' employability; and to put into practice some of the methods, tools and techniques of the computer science related disciplines.

The industry is always on the lookout for students who are vibrant, energetic individuals and ready to accept challenges, attentive, a good academic background, fast learners, open to learning even at work and more importantly, good communication skills. The objective of placement is bridging the gap between industry and academia, through mutually exploring the opportunities for students, professionals and the corporate world at large towards better growth and development.

My course intended learning outcomes are listed as follows:

**i** Develop and apply a range of communication skills for different audiences.

**ii** Appreciate the role and functioning of IT in a business organization through observation of its operations and discovering the practice and standards.

**iii** Demonstrate level of competence in skill-oriented aspect of the program.

**iv** Demonstrate the ability to work effectively, independently and professionally.

**v** Demonstrate the ability to collaborate and function effectively with IT and non IT personnel.

**vi** Develop an attitude to propose solution for problems through independent investigation.

# 2 Description of Company

## 2.1 Type and Scale of Company

Founded in 1987, **Huawei Technologies Co., Ltd.** is a leading global provider of information and communications technology (ICT) infrastructure and smart devices, which have approximately 195,000 employees and we operate in over 170 countries and regions, serving more than three billion people around the world.

Figure 1: logo

## 2.2 Objective of Company

Huawei's mission is to bring digital to every person, home and organization for a fully connected, intelligent world. To this end, we will drive ubiquitous connectivity and promote equal access to networks to lay the foundation for the intelligent world; provide diversified computing power to deliver ubiquitous cloud and intelligence; build powerful digital platforms to help all industries and organizations become more agile, efficient, and dynamic; redefine user experience with AI, offering consumers a more personalized and intelligent experience across all scenarios, including home, travel, office, entertainment, fitness and health.

# 3 Description of Department

## 3.1 Theory Lab of Huawei in Hong Kong Research Center

Huawei Hong Kong Research Center was established in 2018, focusing on chipsets, software engineering, AI, and theoretical researches.

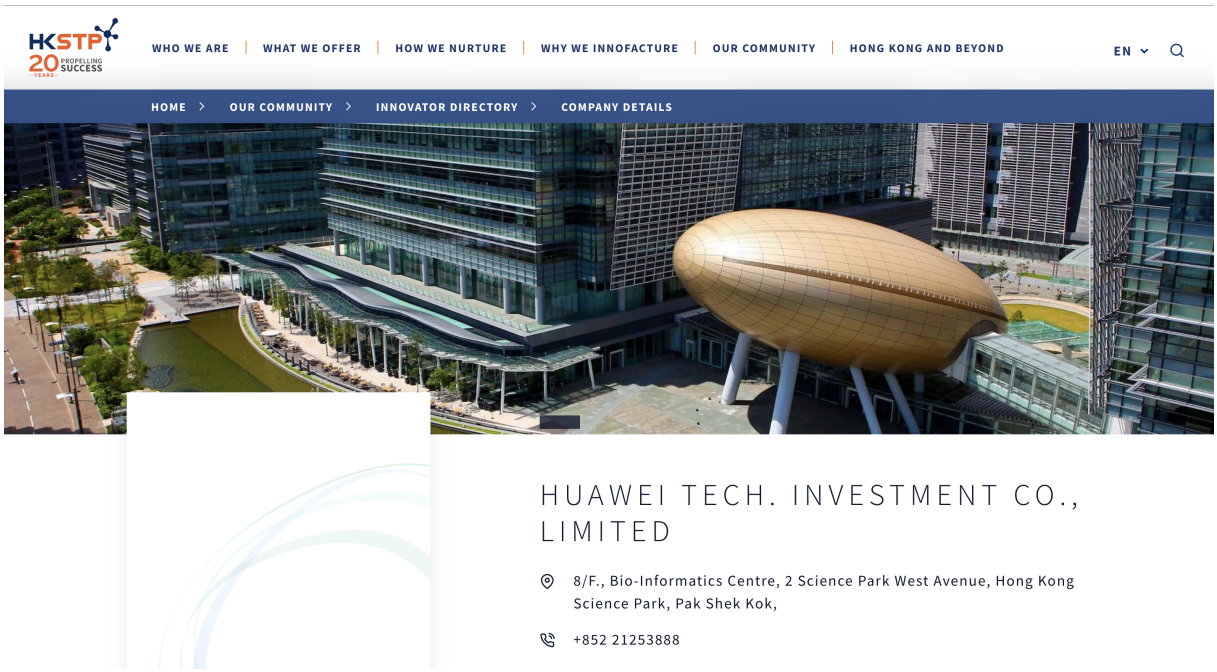


Figure 2: Huawei theory lab in HKSTP

At Theory Lab of Huawei in Hong Kong Research Center, opportunities will be provided to work on world-class challenging problems. Employers will work in a multi-culture environment with talents from all over the world graduated from top universities in Hong Kong, mainland China, US, and other parts of the world. Practical problems from real world systems and research topics that have the potential of guiding the design of the next-generation products are the focus of the daily work. The theoretical and industrial research topics in the lab are in wired and wireless scenarios including but not limited to the following:

- **Optimization theory and algorithm design**
- **Graph theory**
- **Control theory**
- **Information theory**
- **Optimal transport**
- **Large-scale distributed system**
- **AI and machine learning**
- **5G**
- **SDN**
- **AI systems**
- **Cloud computing**
- **Blockchain**
- **Network measurement**

Particularly, I have been working on optimization theory and algorithm design in control theory and optimization group as research intern during the placement program. My main contributions lie in optimizing the linear programming related to the IO module, presolve module, alpha matrix update module, as well as problem modeling of a practical project related to scheduling energy in power grid. More details about work assignment will be mentioned in the following sections for reference purpose. However, some work contributions will not be revealed in full details due to intellectual property and trade secret disclosure issue.

# 4 Work Assignment

## 4.1 Support Modules for LP Optimizer

Linear programming(LP), also called linear optimization, is a method to achieve the best outcome of a linear objective function, subject to linear equality or inequality constraints.

A canonical form of LP can be given as

$$\min C^T X$$

$$s.t. AX \leq 0$$

$$X \geq 0$$

Linear programming can be applied to various fields of study. It is widely used in mathematics, business, economics, and some engineering problems. Industries that use linear programming models include transportation, energy, telecommunications, and manufacturing. It has proven useful in modeling diverse types of problems in planning, routing, scheduling, assignment, and design.

### 4.1.1 File IO Module

MPS(Mathematical programming system) and LP(linear program) are two essential file formats for presenting and archiving linear programming and mixed integer programming(MIP) problems, apart from other well accepted standard file formats.

Basically all commercial LP solvers as well as the open source COIN-OR system accept these file formats. Therefore, a customized file IO routine are required to input and output MPS or LP files.

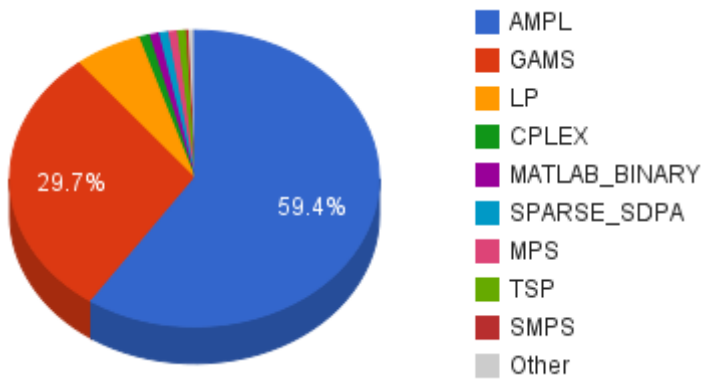


Figure 3: standard file formats

To fill this gap, I together with other colleagues complete the implementations of independent MPS and LP file IO modules for our LP optimizer. Demonstrations of MPS and LP file can be given as

```
NAME          TESTPROB
ROWS
 N  COST
 L  LIM1
 G  LIM2
 E  MYEQN
COLUMNS
    XONE      COST                 1   LIM1                 1
    XONE      LIM2                 1
    YTWO      COST                 4   LIM1                 1
    YTWO      MYEQN               -1
    ZTHREE    COST                 9   LIM2                 1
    ZTHREE    MYEQN                1
RHS
    RHS1      LIM1                 5   LIM2                10
    RHS1      MYEQN                7
BOUNDS
 UP BND1      XONE                 4
 LO BND1      YTWO                -1
 UP BND1      YTWO                 1
ENDATA
```

(a) MPS file

```
Optimize
 COST:     XONE + 4*YTWO + 9*ZTHREE
Subject To
 LIM1:     XONE + YTWO           <= 5
 LIM2:     XONE         + ZTHREE >= 10
 MYEQN:         - YTWO + ZTHREE  = 7
Bounds
        XONE <= 4
 -1 <= YTWO <= 1
End
```

(b) LP file

### 4.1.2 Presolve Module

Presolve is a process where the problem input is examined for logical reduction opportunities. The goal of presolving is to reduce the problem size. A significant reduction in problem size typically translates to a reduction in overall running time of a particular LP solver. So far, I am still working on the implementations of the independent presolve module, which is postponed as scheduled. For more information about linear programming

presolve, you may want to refer to IBM document: Introduction to presolve

## 4.2 Data Structure Implementation

The scale of problems can be extremely huge in real practice, therefore traditional two dimensional array cannot fulfill the requirements of storing a significant large alpha matrix. To overcome the difficulties, general approaches to solving the problem are implemented, including triplet storage and sparse vector. Again, implementation details will not be covered in the following sections.

### 4.2.1 Triplet Storage

Triplet storage maintains a minimal triplet structure to store a matrix. The three vectors include **start**, **index** and **value** vector, which maintain the start nonzero index for each columns, the row index for each nonzero entries and corresponding coefficients respectively. It is worth noting that by **triplet storage**, we refer to the column-majored version of implementation, which is also known as CSC matrix. It can be claimed that it is much more efficient in terms of memory space when the original matrix is very sparse with a large scale of zero entries. A trivial example of triplet storage is as follows.

original matrix:

$$[[1, 0, 2], [0, 2, 3], [1, 4, 5]]$$

column-majored sparse storage:

**start:**

$$[0, 2, 4, 7]$$

**index:**

$$[0, 2, 1, 2, 0, 1, 2]$$

**value:**

$$[1, 2, 2, 3, 1, 4, 5]$$

#### 4.2.2 Sparse Vector

The idea of sparse vector is rather trivial. For each and every nonzero entry, a tuple $(index, value)$ is stored. The main difficulties are to search for an entry with a specific **index** or **value** and to implement basic operations between two or more sparse vectors, for instance, sparse vector addition, subtraction, scale multiplication and dot product, so on and so forth.

### 4.3 Scheduling Energy in Power Grid

My other contributions mainly lie in optimizing how to schedule energy flow in power gird. The problem formulation is still on going and open source solvers are used in the process to verify the overall performance of different models.

## 5 Acknowledgements

I would like to thank my work supervisor ZHANG Fan, Michael and my academic supervisor Kenneth Lee for their support during the placement. Also, I want to express my appreciation to all the reviewers of this report.