



# Advanced Network Management

a.k.a.

## AIOps: Autonomous IT Operations or AI for IT Operations

course#: 80240663

Fall 2020



ANM 2020



Instructor: Dan Pei  
[peidan@tsinghua.edu.cn](mailto:peidan@tsinghua.edu.cn)

Teaching Assistant:  
Qianyu Ouyang [oyqy2019@mails.tsinghua.edu.cn](mailto:oyqy2019@mails.tsinghua.edu.cn)



*Please scan QR code to join class WeChat Group*

# Roadmap

- **Self-Introduction**
- Course Logistics
- What is AIOps?
- Course Coverage (Website)
- Assignments and Projects

# How to pronounce “Pei”?

Just pronounce “Pei” as “**Pay**”

In fact, just call me “Dan”

Louvre Museum



I-M **Pei**: the famous architect who  
designed the glass pyramid



# About the Instructor

- Tenured Associate Professor.
- UCLA Ph.D. Best Ph.D. Thesis Award in UCLA CS in 2005.
- Joined Tsinghua CS Department in December 2012
- Homepage: <http://netman.aiops.org/~peidan>
- Previously a Principal Researcher at AT&T Research, a co-founder and founding CEO of a mobile health company in Beijing, before joining Tsinghua.
- Supervised interns from CMU, Cornell, Princeton, UCLA, GaTech, Michigan, Northwestern etc. Now @ Google, MSR, IBM, Purdue, Northeastern, HKUST
- ACM/IEEE Senior Member

# My Research Group @ Tsinghua: NetMan

- Currently advising 22 Ph.D. and M.S. students at Tsinghua.
- 2 affiliated assistant professors and 4 post-docs
- Graduated 11 PhDs & 3 Masters ( 3 went to MSRA, 4 became assistant/associate professors, 3 became CEO/CTO/director in a startup, 1 went to Alibaba, 1 went to Meituan, ... )



# Industry Collaborators



## Publications:

100+ AIOps papers and 20+ issued US Patents. Published in SIGCOMM、WWW、KDD、SIGMETRICS、TON、INFOCOM、IMC、CoNEXT、IJCAI etc.

Research results are covered by technology media such as MIT technology Review, Hacker News, Mother Board, Morning paper, and many Chinese media.

The screenshot shows a mobile browser displaying a news article. At the top, there is a red circle highlighting the title "the morning paper". Below the title, a subtitle reads "an interesting/influential/important paper from the world of CS every weekday morning, as selected by Adrian Colyer". The main content of the article discusses "Unsupervised anomaly detection via variational auto-encoder for seasonal KPIs in web applications". It includes a citation: "Unsupervised anomaly detection via variational auto-encoder for seasonal KPIs in web applications Xu et al., WWW'18". Below the citation, it says "(If you don't have ACM Digital Library access, the paper can be accessed either by following the link above directly from The Morning Paper blog site, or from the WWW 2018 proceedings page)." The text continues to describe the research problem and its application to Alibaba's web application KPIs.

The screenshot shows an email inbox. The subject of the top message is "Final Thesis". The message body starts with "Dear Professor Dan, dear Haowen," followed by a thank you note for hosting at THU in July. It then states: "Attached I am sending you my final thesis on extensions of hierarchical categorical VAEs/GMVAEs. Based on changes to the implementation of the categorical variable and a few experiments on objective weights, the final model achieved best unsupervised test accuracy reported for MNIST to date. This result would not have been possible without the great environment and discussions in your lab." The message ends with "Thank you, Swen".



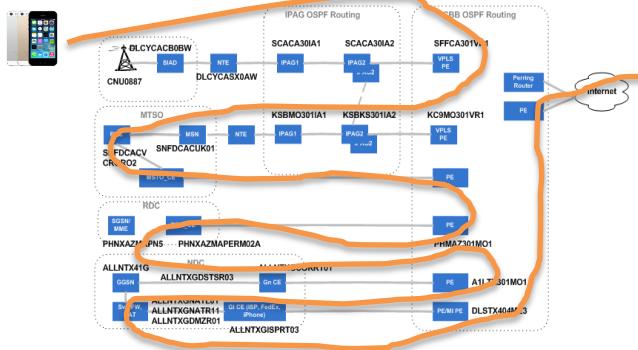
Topics+ Top Stories Mag:

### Data Mining Solves the Mystery of Your Slow Wi-Fi Connection

Chinese researchers have worked out the reasons for why Wi-Fi can take so long to connect.

# AIOps : Autonomous IT Operations through Machine Learning

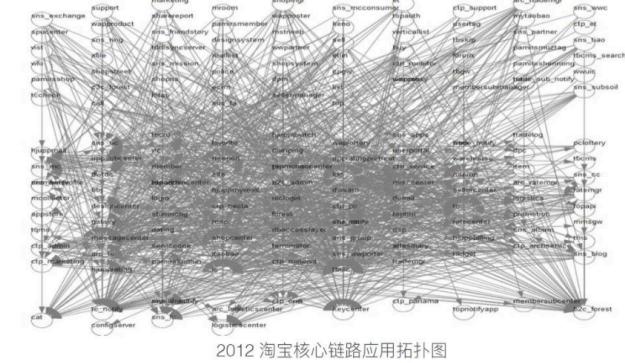
## Large & complex access network



## Large & complex data center

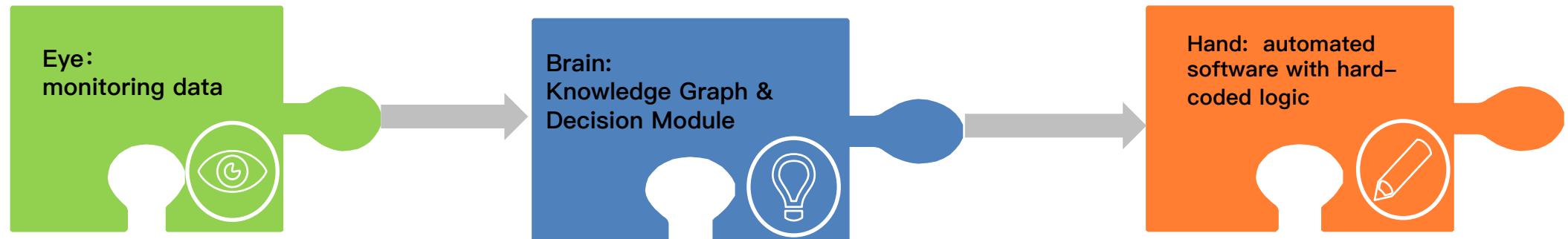


# Large & complex application software



- Imagine that you are running an Internet-based service with hundreds of thousands of servers and many software modules, a large, complex, cross-layer, and rapidly evolving distributed system.
  - You want to achieve 99.999% service reliability, but machine-generated monitoring data and hundreds of operators (IT operation engineers) alone won't get you there, because of the high complexity and sheer scale of the software/hardware system and the vast amount of machine-generated data.
  - Machine learning is the direction to enable Autonomous IT Operations autonomous.

# AIOps Architecture & Algorithms



- The major topics of AIOps often coincide with its more general counterparts in Machine Learning:
  1. Anomaly Detection in Time Series, Logs (semi-structured text), Traces (program execution trace), and Graphs
  2. Anomaly Localization
  3. Failure/Event Prediction
  4. Causal Inference and its application in Root Cause Analysis
- State-of-art Machine Learning Algorithms are applied to solve the unique challenges in AIOps:
  1. Deep Neural Networks for Time Series or Sequence
  2. Deep Generative Model (VAE, GAN)
  3. Deep Reinforcement Learning
  4. Natural Language Processing
  5. Causal Inference

# PRINCIPLES

## RAY DALIO

"Ray Dalio has provided me with invaluable guidance and insights that are now available to you in *Principles*."

—BILL GATES

"I found it to be truly extraordinary. Every page is full of so many principles of distinction and insights—and I love how Ray incorporates his history and his life in such an elegant way."

—TONY ROBBINS

#1 NEW YORK TIMES BESTSELLER

INFOCOM 2012

Principles for Success: "The Five Step Process" | Episode 3

The diagram illustrates the "Five Step Process" for success. It features five numbered steps: 1 GOALS, 2 PROBLEMS, 4 DESIGN, 3 DIAGNOSIS, and 5 DO IT. Each step is accompanied by a small illustration of a person in a dynamic pose. A large black circle encloses steps 4 and 5. The background shows a landscape with mountains and clouds.

Principles for Success: "The Five Step Process" | Episode 3

1 GOALS

2 PROBLEMS

4 DESIGN

3 DIAGNOSIS

5 DO IT

Unsupervised Learning

Transfer Learning for concept drift

EPISODE 03

PRINCIPLES FOR SUCCESS

(a) KPI and change score

(b) change score and threshold

SSRE 2018 Best Paper

www.infocom2012.com

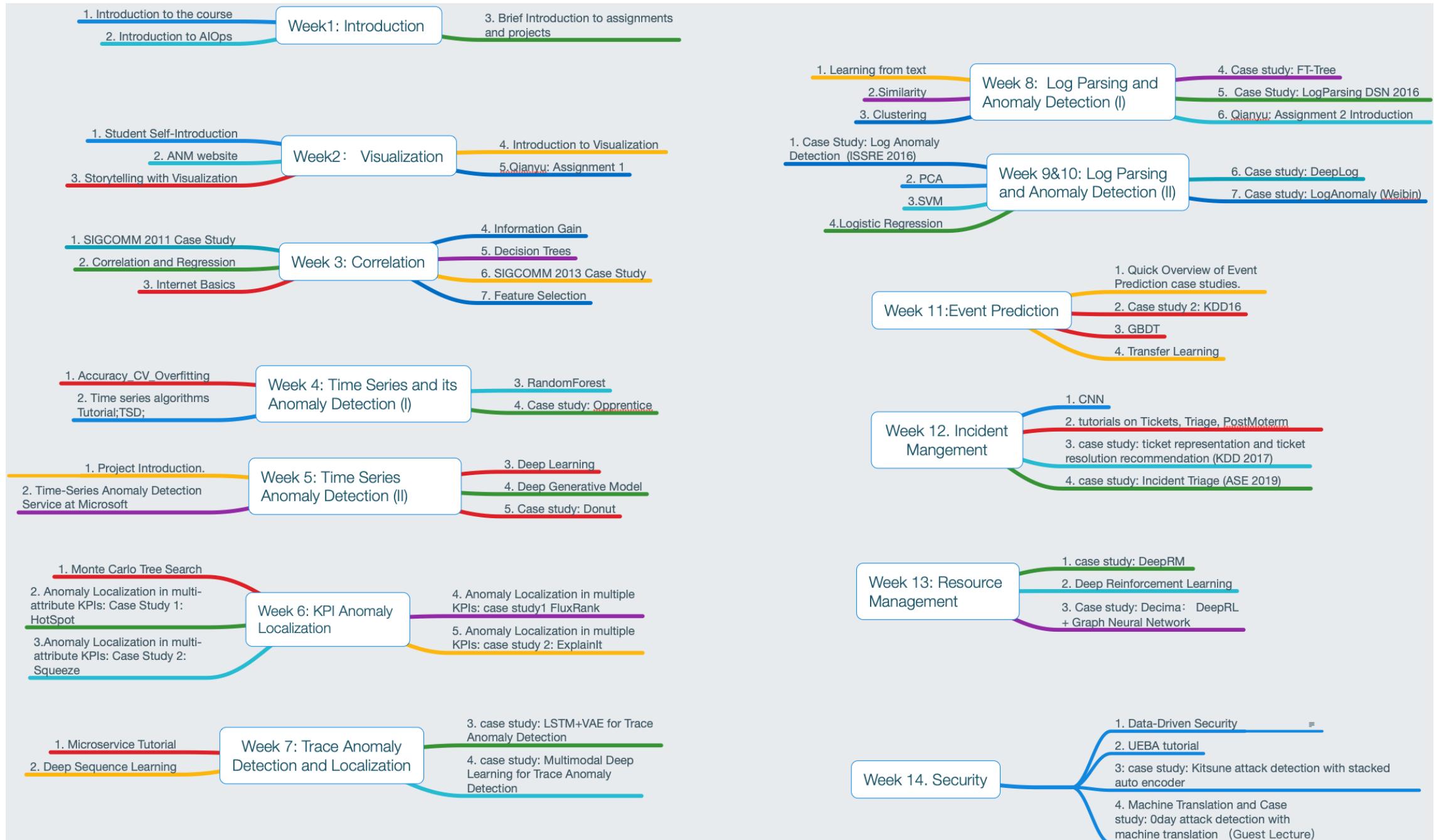
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# Summary

- AIOps is an **interdisciplinary** research field between **Machine Learning** and **Systems/Networking**, which is why this course had this historical title “Advanced Network Management”. If you are interested in learning how a large distributed system can be better run with the help of machine learning, this course is for you. If you want to learn **how machine learning can help solve challenging problems in a very complex system**, this course is for you.
  - This course will cover the latest progress in major topics of AIOps using **case studies** from recent research papers in top conferences in all major computer science fields, including Machine Learning, Data Mining, System/Networking, Software Engineering, Database, Multimedia, etc.
  - Through these case studies, we will show how the latest Machine Learning Algorithms are applied to solve the unique challenges in AIOps. The **basics of these Machine Learning** algorithms will be briefly **reviewed in an easy-to-understand way**, without going through the detailed theory behind them. Thus by the end of the course, you will be able to learn **roughly how these algorithms work, and how it can be applied to solve real-world problems**.





# Course Requirements

- Course website: <http://course.aiops.org/>
- **Prerequisites:**
  - You are expected to be familiar with at least one programming language, preferably Python.
    - If not, please quickly learn one.
  - You don't have to have previous machine learning knowledge.
- Encourage interaction and discussion
  - stop me and ask questions at any time! (online students please “raise your hands” on Zhumu)
  - You get credits for interaction (Yes, our TA notices your interaction)

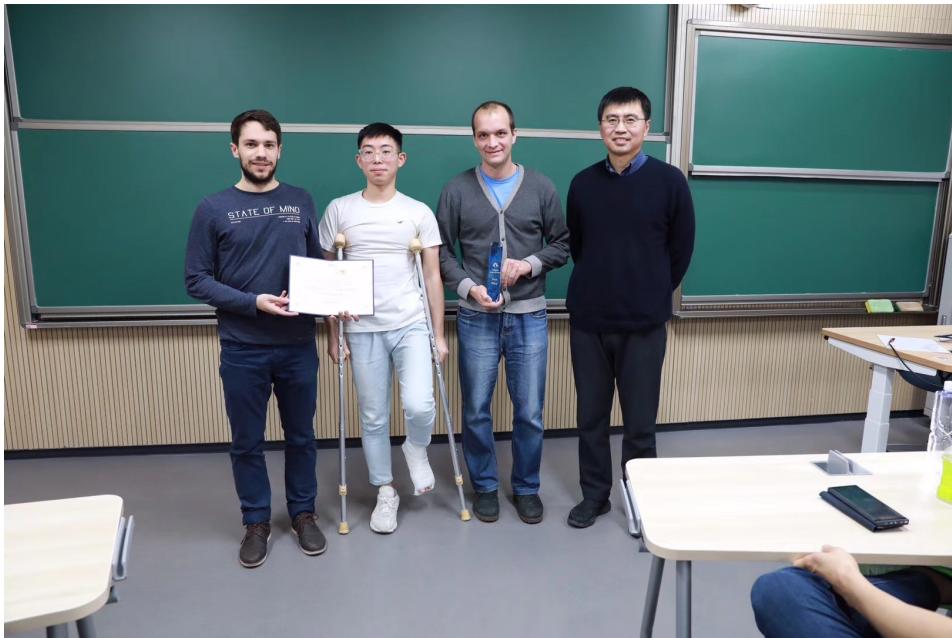
# Course Info

- Time: Wednesday **7:20pm-9:45pm** (Weeks 1-15)
  - 15 classes, each has three 45-minute sessions.
- Session 1: Machine Learning Basics
- Sessions 2 & 3: AIOps case studies
- Office Hours:
  - After every class.

# Grading:

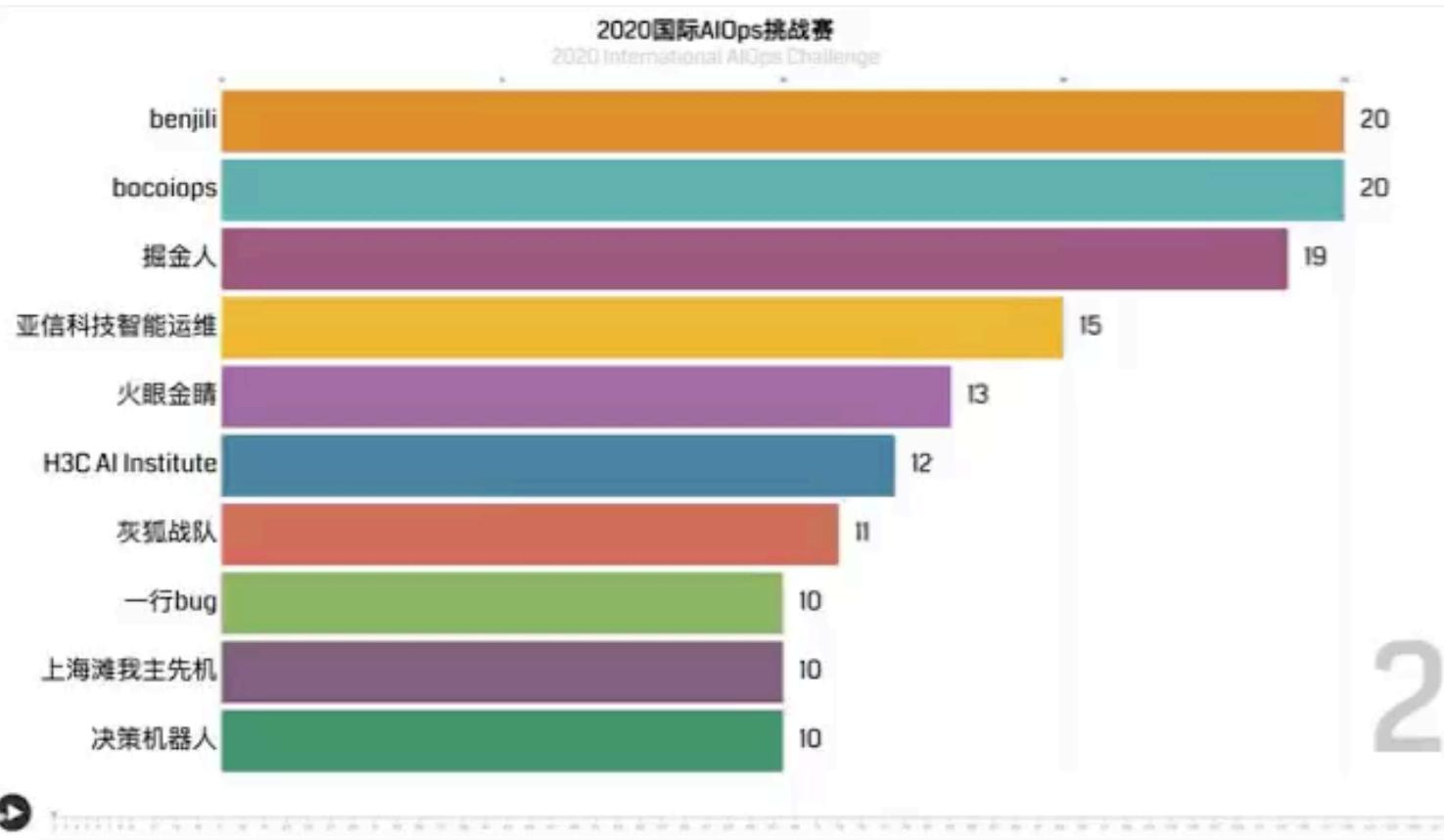
- Attendance & Interaction: **10%**
  - Presence: 0.5% for each lecture in Weeks 3-14. 6% in total
  - 1% for each question asked or answered. 4% maximum.
- Assignments: **30%** (each student finishes each assignment alone)
  - Assignment 1: 10%
  - Assignment 2: 20%
- Project: **60%** (A project team of 2 or 3 students)
  - Ranking in algorithm competition & report: 50%
  - Presentation in week 16 (scored by all students, TA, and instructor): 10%
- The final grade will be in letter grading scale (e.g., A,B,C,D)

# Project: Algorithm Competition

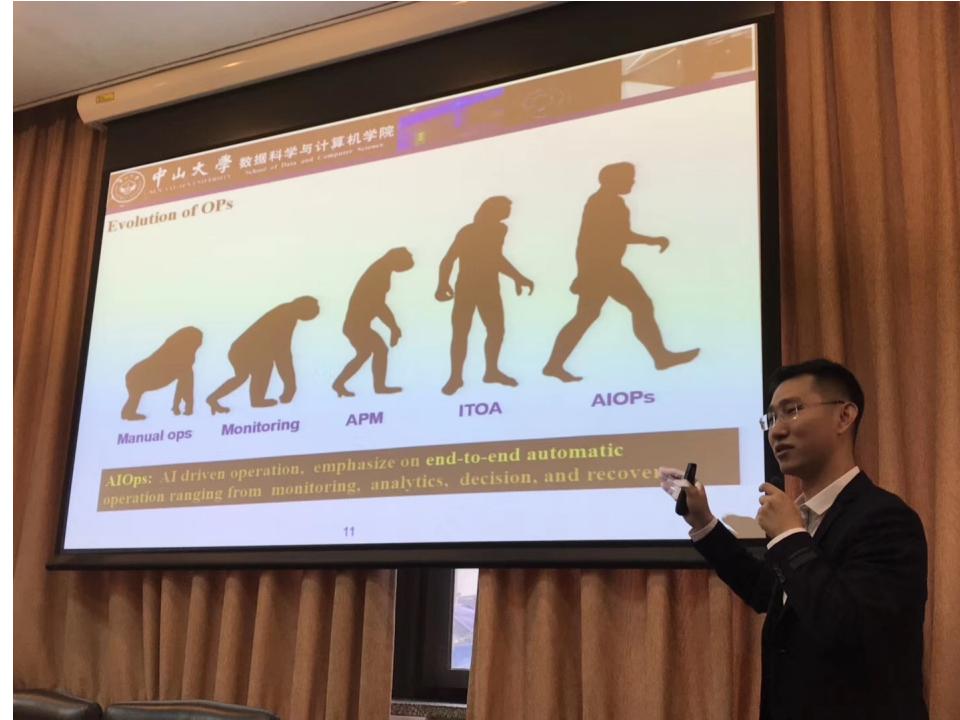


# Project: Algorithm Competition

Based on 2020 AIOps Algorithm Competition



# Invited Talks



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# Case Studies: Papers and Slides

- Already Posted on the course website
  - Maybe updated before each class, so please check the website weekly.
- Lecture Coverage
  - You were supposed to read these papers carefully
- Reading List
  - Relevant papers, read them if you have time

# Why reading papers/case studies?

- Purpose: background knowledge, algorithm, methodology, writing, design principle, solution inspiration, evaluation methodology for the problem you are working on, and (sometimes) vision.
- My strongly biased personal opinion: Papers are not for finding topics for your next paper.
  - Instead, “From Practice, into Practice”: E.g. try existing algorithms in papers in practice to discover where it does not work

# What's a good paper

- A new and important problem, solid solution.
- Old and challenging problem, a new *simple but elegant* solution, with straightforward insight and intuition behind it.

# Using Google Scholar to find relevant papers (demo)

- Browse latest proceedings of relevant conferences, find one relevant paper  $p$ . *Relevant paper set  $S=\{p\}$*

for (each new  $p$  in  $S$ ) {

    Browse  $p$ 's references, and put relevant ones into  $S$ ;

    Browse  $p$ 's citations in Google Scholar, and put relevant ones into  $S$ ;

}

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Spring 2017



Fall 2018



# Enjoy the course!

Spring 2018



Fall 2019

