

# Northwestern | THE GRADUATE SCHOOL

## Application for Admission

App Type **New Student** Submitted Date **11-29-2018** App ID# **79172534**

Intended **Full-time** Status Entry **Fall 2019** Quarter Prior TGS Applicant (Program)

Last Name **LI** First **KE** Middle

Gender Pronouns (US only) Birthdate **04-21-1997** Gender **Male**

Program **Computer Science: MS** Secondary PhD (MEAS Only)

Specialization/Area of Interest **Systems and Networking** MS Consideration (MEAS Only)  
Cluster

JD/PhD No DPT/PhD No Fee Waiver US Vet/Active Forces

Ethnicity Hispanic

Citizenship **CHINA** Visa

Citizenship Status **International Student**

Country of Birth **CHINA** Green Card #

Current Address  
**zijingang campus, zhejiang university**  
**xihu district**  
**Hangzhou, 310058**  
**CHINA**

Permanent Address  
**zijingang campus, zhejiang university**  
**Hangzhou**  
**CHINA**

Current Phone **+8618867158066** Permanent Phone

Cell Phone Preferred Phone **Current Phone Number**  
Number

Email Address **likeapplymail@163.com**

Previous Institution	From	To	Field of Study	Level	Degree	Date
<b>Zhejiang University</b>	<b>09-01-2015</b>	<b>06-01-2019</b>	<b>Software Engineering</b>		International Undergraduate Degree	

Cumulative UG GPA	<b>3.59</b>	UG Junior/Senior Year GPA	<b>3.79</b>
Cumulative UG GPA - Unconverted		Max UG GPA Scale	
Cumulative Grad GPA			
Cumulative Grad GPA - Unconverted		Max Grad GPA Scale	

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Letters of Recommendation

1. **Kai Bu** **kaibu@zju.edu.cn**
  2. **Dong Wang** **dwang5@nd.edu**
  3. **Tianlei Hu** **htl@zju.edu.cn**
  - 4.
  - 5.
- 

Are you interested in studying with specific faculty members? (List names below)

1. First Name **Yan** Last Name **Chen**
  2. First Name **Peter** Last Name **Dinda**
  3. First Name Last Name
  4. First Name Last Name
- 

Please indicate the highest level of education completed by your parent(s) or guardian(s) (the one or two people most responsible for raising you)

First individual's highest level of education completed:

If other, please explain:

Second individual's highest level of education completed:

If other, please explain:

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Language

Reading

Writing

Speaking

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Self-Reported Test Scores

GRE Gen **09-14-2018** Verbal **153** **61** Quant **170** **96** A.W. **3.5** **41**

GRE Sub    LSAT

TOEFL **08-25-2018** Ovr **106** Read **28** List **28** Speak **22** Writ **28** IELTS  Ovr

GMAT  Tot   Verb   Quant   A.W.   I.R.

MCAT  Bioscience   Verbal   Physical Science

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Please list any honors you have been awarded  
**The Third Level Academic Scholarship [25%]**  
**Honorable Mention, COMAP's Mathematical Contest in Modeling**

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Have you applied for or been awarded an external fellowship?

Yes  No  If yes, please specify:

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Please describe your plans for the future.

I'm interested in distributed system related fields and software engineering now. And, I find myself interested in developing beautiful and efficient software systems. All these reasons make my mind to study aboard, so it is most likely that I will look for a job as a software engineer which can realize my dream.

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Other Universities Applied (in preferred rank order)

- |                     |                   |
|---------------------|-------------------|
| 1. School Drop Down | 5. School "other" |
| 2. School Drop Down | 6. School "other" |
| 3. School Drop Down | 7. School "other" |
| 4. School Drop Down | 8. School "other" |
- 

Academic misconduct? Yes  No  Convicted of crime? Yes  No

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If answered yes, applicant is asked to upload explanation. If uploaded, explanation will be attached to end of application PDF.

## **Statement of Purpose**

I was confusedly wandering in the first two years of my undergraduate life at Zhejiang University, following the steps of others, not knowing what I really wanted to do nor what I really loved. Thus, it's not surprising that I did a poor job in these two years and experienced many failures.

My turning point came in the sophomore year when I got a chance to lead a team in the software engineering course to build a website . It was my first time to handle a large project, instead of merely writing a single program. I learned a lot along the way of being a leader. I managed to understand the front-end and back-end frameworks, comprehended the logic of website operation based on Django, and learned how to use HTML and JavaScript. Though looked simple, it was hard for me to find a breakthrough point at first. However, instead of giving up, I found myself energetic to handle these challenges. At first, I built a simple demo to understand the basic working principles of the system. After mastering these, I taught them to my teammates. Meanwhile, I designed the overall architecture, divided it into several modules and assigned each to the most proper teammates. Through our joint efforts day and night, we accomplished an online evaluation platform which supported automatically generating test paper from questions in the database for students to accomplish tests online. Moreover, I added a difficulty parameter to each type of question and wrote a random algorithm to empower the platform for creating papers with different difficulty level. My efforts won me general acceptance and respect. The experience enlightened me, "I can do well". More than that, I found myself greatly enjoying the process of software development, and this project has inspired my ambition to be an excellent software engineer.

At the beginning of my senior year, I was lucky to meet Dr. Kai Bu on his course of Computer Architecture. With my ambition and confidence, I bravely asked Dr. Kai for a chance to partake in his Memcloak project and he agreed my join. The project aimed to avoid the users' access mode leakage when the attacker wiretapped memory bus from CPU to memory. Under Dr. Kai's instruction, I did a comprehensive literature survey, focusing on my target instead of getting lost in the details, and simplified the theoretical methods summarized from papers. Traditional methods use a tree-like data structure to obfuscate the memory access, yet bring a large memory usage and time consumption. Integrating the knowledge from the course and brainstorming with the teammates, I proposed a new idea that we could imitate the mechanism of page-table by implementing a hardware component to combine the functions of TLB and caches. I implemented the design and tested it on Gem5, an open source computer architecture simulator. During the process, I became more familiar with C++ programming and my analysis ability of large-scale open source software was greatly enhanced. Because gem5 is an asynchronous system, it was difficult to debug using traditional methods, but with a clear understanding of our algorithm and the structure of the code, I could screen out possible bugs by a thorough check of the whole program logic in my mind or on paper. Through the project, I found myself enjoy programming and willing to take all kinds of challenges and I indeed have the ability to chase my dream, a good software engineer.

Meanwhile, through my dedicated study at Zhejiang University, especially in the senior year, I have laid a solid foundation in computer science, from the bottom (e.g., computer organization) to a higher level (e.g., object-oriented programming), with sufficient math knowledge (e.g., linear algebra, discrete mathematics, and probability theory). I also obtained advanced knowledge in computer system and software development with

courses like Software Engineering, Operating System, Computer Network, and Database System. Besides, I had a deep exploration about the block-chain due to my interest in it, from the technologies to the usage. All the courses and researches deepened my love and excitement about my major. I highly appreciate the old saying: system building is like art designing. I was deeply surprised and attracted by the creativeness and ingeniousness behind modern computer architecture designs such as the page-table mechanism, the OSI model and so on. All my experiences have fostered me a strong determination to build beautiful and efficient software systems in the future by myself.

To gain more preparation for my future abroad study, this past summer, I participated in a research project on detecting and filtering hateful chats in YouTube Live Streams using machine learning under the instruction of Dr. Dong Wang at the University of Notre Dame. By reading the papers related, we designed our own architecture. First, we used three modules to label each chat by explicit words, sentiment and context. Combined with output of Word2Vec, these three labels would be the input of the final classifier model. At first, taking charge of the Explicit-Analyzer, I simply try to directly match keywords with a thesaurus of dirty words. However, the matching performance was bad as the words users use online are usually not formal and contain many mistakes, with even many new words they created by themselves. So I changed the model I use, turned to a Naive Bayes model which created a thesaurus by some training data and kept updating each word's frequency. Tools of eliminating plural and voice were also used. The supervised model achieved a good performance. Then, I developed a Sentiment-Analyzer by myself to judge if a sentence was hateful or cheerful, based on the score of sentences which was marked through analyzing the frequency of phrase (bigram) and the distance between two phrases. Besides, I wrote a Context-Analyzer module, trying to find out dirty chats by analyzing the interactions between them, since the circumstances that people attack each other usually generate bad words. However, by the end of the summer, the output of Word2Vec was still not acceptable, because the data was too imbalanced and irregular. During this short period, deeply involved in the research and laboratory life, I was captivated by the academic atmosphere there. I believe that study abroad will definitely be a great choice to improve myself and to realize my dream.

With my hard-work and endeavor in the last three semesters, I have developed from a confused and diffident boy to an energetic and confident student prepared to pursue his dream. Out of my interest in systematic software development, I participated in the internship of game server development in Netease Game Pangu Studio, from where I learned a lot about distributed systems. I also chose my graduation project as to develop a distributed server system to further sharpen my understandings in this area. Determined to be a great software engineer and ‘making arts’ in the future, I decide to seek education abroad without hesitation. With its prestigious research reputation, abundant high-quality courses and prominent professors, Northwest University is the right place for me. I believe I can receive the best training for my future career and get ample opportunities for practice through your Master of Science in Computer Science program. With a steadfast and sincere heart, I hope you find my academic experiences impressing enough, making me an ideal candidate for the program to strive for my dream!

# Zhejiang University

## Student's Academic Records

Name: LI Ke	College/Dept.: College of Computer Science & Technology	Speciality: Software Engineering	Student ID: 3150103729
Sex: Male	Birthday: 04/21/1997	Birth Place: Sichuan	Years of Program: 4 Years
Academic Year 2015-2016	Ordinary Differential Equations	Entrance Date: 09/01/2015	Graduation Date: 06/30/2019
Courses (1st Term)	*Cr *Sc	Communication Skills in Information Technology	Probability and Mathematical Statistics
Military Training	2. 0	Constitutional Law	Discrete Mathematics and Application
A CONCISE HISTORY OF WESTERN MUSIC	1. 5	Courses (1st Term)	Principles of Computer System△
Linear Algebra	2. 5	Integrate Practice for Courses I	Principles of Computer System△
College English Band III	3. 0	Advanced Chinese	Principles of Computer System△
Radio Direction Finding	1. 0	Overview of Mutual Fund	Principles of Computer System△
Military Theory	1. 5	Software Quality Assurance & Test	Principles of Computer System△
Calculus I	4. 5	Art of Photography	Principles of Computer System△
Mental Education and Foundation of Law	2. 5	University Physics (A) II	The History of Eastern Civilizations
Fundamentals of Programming	3. 0	College Physics Experiment	C+
Modern Chinese History	2. 5	Marketing	Operating System
Engineering Graphics	2. 5	Engineering Training	Intro. to Mao Thought & Theoretical System of China Socialism
Courses (2nd Term)	*Cr *Sc	Digital Logic Design	4. 0
Calculus II	2. 0	Fundamentals of Data Structures	82
Economic Law	1. 5	Object-Oriented Programming	Operating System
College English Band IV	3. 0	Principles of Information Security	System of China Socialism
Situation and Policy I	1. 0	Courses (2nd Term)	Java Application Design
Basketball (Mid Level)	1. 0	Principles of Information Security	Fundamentals of Software Engineering
Calculus III	1. 5	Advanced English Writing	3. 5
University Physics (A)	1	Introduction to Global Security	95
Solfeggio	2. 0	Market	Software Requirement Engineering
History of Foreign Law	3. 0	Introduction to the Principle of Marxism	3. 5
History of World Civilizations I	2. 0	Advanced Data Structure & Algorithm Analysis	92
Program Design Project	2. 0	Principles of Computer System	Ordinary Differential Equations△
Credits Required for Graduation:	160+4+6	Credits Obtained:	168
Three grade systems are used simultaneously in Zhejiang University, specifically as follows(*C=Credits, *Sc=Score):			Degree Granted:
1.The percentage system: Above 60 is passing, 100 is full mark.			
2.Five degree grading:Excellent(A),Good(B),Fair(C),Passing(D),Failed(F);			
3.Two degree grading:Passing(P),Failed(F);			
4.Courses identified with "△" are retaken and calculated into GPA according to the highest score.			
5.Courses identified with "▲" are transferred from partner universities.			
RECOGNITION INSTRUCTION: 1.ZHEJIANG UNIVERSITY is microprinted on the lower right corner as a line, they can be seen under the magnifying glass.			
2.The fluorescent school badge of ZHEJIANG University on the higher left corner will appear under the UV light. 3.The words "ZJU" on the center of the report will turn purple under the sunlight. 4.This style transcript has been formally in use since September 1,1999.			

Academic Year 2016-2017

Academic Year 2016-2017					
Courses (1st Term)	*Cr	*Sc	Database Systems	4. 0	76
Ordinary Differential Equations	1. 0	72	Information Technology	2. 0	80
Constitutional Law	3. 0	76	Discrete Mathematics and Application	4. 0	78

Academic Year 2017-2018

Academic Year 2017-2018					
Courses (1st Term)	*Cr	*Sc	Principles of Computer System△	4. 0	87
Communication Skills in Information Technology	2. 0	80	Principles of Computer System△	2. 5	87
Field Trips	1. 0	83	Principles of Computer System△	3. 0	92
Overview of Mutual Fund	1. 5	91	Principles of Computer System△	4. 0	A
Project Training	3. 0	92	Principles of Computer System△	4. 0	A
Practice Ability & Quality Development	2. 5	87	Principles of Computer System△	4. 0	A
Computer Architecture	3. 5	93	Principles of Computer System△	4. 0	A
The History of Eastern Civilizations	3. 0	C+	Principles of Computer System△	4. 0	A
Operating System	5. 0	84	Principles of Computer System△	4. 0	A
Intro. to Mao Thought & Theoretical System of China Socialism	4. 0	82	Principles of Computer System△	4. 0	A
Computer Networks	4. 0	87	Principles of Computer System△	4. 0	A
Java Application Design	2. 5	73	Principles of Computer System△	4. 0	A
Fundamentals of Software Engineering	3. 5	95	Principles of Computer System△	4. 0	A
Software Requirement Engineering	3. 5	92	Principles of Computer System△	4. 0	A
Bond Trading System	1. 5	88	Principles of Computer System△	4. 0	A
Service Science	2. 0	80	Principles of Computer System△	4. 0	A
Foreign Exchange Trading System	1. 5	87	Principles of Computer System△	4. 0	A
Database Systems△	4. 0	85	Principles of Computer System△	4. 0	A
University Physics (A) I△	4. 0	84	Principles of Computer System△	4. 0	A
University Physics (A) II△	4. 0	84	Principles of Computer System△	4. 0	A
Artificial Intelligence	3. 5	84	Principles of Computer System△	4. 0	A
Secure Programming	2. 5	92	Principles of Computer System△	4. 0	A
Mobile Platform Development	3. 0	94	Principles of Computer System△	4. 0	A

Overall GPA:3.59/4.0(82.96/100)  
The third year GPA:3.79/4.0(85.65/100)

Associate Provost:

Registrar:

Date Issued:11/19/2018

# Ke Li

No. 38 Zheda Rd., Xihu Dist., Hangzhou, Zhejiang, China || kli@zju.edu.cn || (86)18867158066 || <https://tomatolike.github.io>

## Education

**09/2015-06/2019 B. Eng. in Software Engineering (GPA: 3.59/4.0 Junior: 3.79/4.0), Zhejiang University(ZJU)**  
The Third Level Academic Scholarship (25%)

## English Proficiency

08/25/2018 TOEFL: 106= R28 + L28 + S22 + W28      09/14/2018 GRE: 323+3.5= V153+ Q170 + AW3.5

## Papers

Weixin Liang, Kai Bu, **Ke Li**, Jinhong Li, Arya Tavakoli, "Mem-Cloak: Practical Access Obfuscation for Untrusted Memory," *In 2018 Annual Computer Security Applications Conference (ACSAC'18), December 3-7, 2018, San Juan, PR, USA*. ACM, New York, NY, USA, 11 pages.

Daniel (Yue) Zhang, Lanyu Shang, Biao Geng, Shuyue Lai, **Ke Li**, Hongmin Zhu, Md Tanvir Amin, Dong Wang, "FauxBuster: A Content-free Fauxtography Detector Using Social Media Comments," IEEE International Conference on Big Data, 2018.

## Research Experience

**07/2018-08/2018 University of Notre Dame iSURE Summer Research Program**

Advisor: Assistant Professor Dong Wang, Interdisciplinary Center for Network Science and Application  
Description: Detected and filtered the hateful chats in Youtube Live Streams;  
Tools: Python, Selenium, Textblob, googletrans, sklearn  
Duties Read papers for baseline and related works, then design the architecture, trying to realize a incremental learning model.  
Built crawler which collects 100 thousands chats from Youtube live streams, and designed the formal structure of them and implemented formalization.  
Built Explicit-Analyzer based on words frequency using Naïve Bayes model, finding out those chats with dirty words.  
Built Sentiment-Analyzer based on bi-gram extracting.  
Built Context-Analyzer based on chats interactions, trying to find out hateful chats without specific dirty words in it.  
Connect them with modules(XGBoost, Radom Forest, SVN, etc.) from sklearn and evaluate the performance.

**09/2017-05/2018 Research on the Security Technology of Data Transportation from CPU to Memory**

Advisor: Assistant Professor Kai Bu  
Description: To avoid leakage of user's access mode when attacker wiretapped memory bus from CPU to memory;  
Tools: Gem5 simulator, Python, C++  
Duties Studied Gem5 simulator and analyze the code structure of it and the process of data transmission.  
Designed the architecture of our algorithm and the whole process from sending data in CPU module to receiving data in memory module.  
Used Gem5 to implement the algorithm in simulator, building the whole components of our module, including cache, page-table and debug in a asynchronous system.

**06/2018 Database Systems: A Simple Version of MySQL Construction**

Description: Build a simple version of MySQL using C++, based on SQL language.  
Duties Built index-manager, which managed generation and modification of indexes.  
Built buffer-manager, which managed limited memory resources and provide interfaces to other modules.  
Connected the other modules (Translator, Catalog, Record) together and fixed all bugs, as the team leader.

**02/2018 Honorable Mention, COMAP's Mathematical Contest in Modeling (45%)**

Duties: Normalized the downloaded data from txt files into structural data;  
Designed and built the model, adjusted parameters, and searched materials to confirm the model results.

**03/2018-06/2018 Two iOS Application Development (Xcode, Unity3D, Swift, Objective-C)**

# Ke Li

No. 38 Zheda Rd., Xihu Dist., Hangzhou, Zhejiang, China || kli@zju.edu.cn || (86)18867158066 || <https://tomatolike.github.io>

Description: Developed a musical game where user can catch up with the music rhythm by “eating” the fruits on screen. The fruits will appear and disappear on screen following the music rhythm.

Duties: Analyzed face outline from camera and captured the closing and opening of mouth; built the rules and logics of objects’ movements; checked whether the user “eat” the objects on time.

## 09/2017-01/2018 Software Engineering Fundamentals: Teaching Management Web System

Tools: Python, Django, Bootstrap, MySQL, Scrapy, Selenium, UML

Duties: Acted as a leader to manage the team and distributed work according to software engineering methods; Communicated with customers, finished requirement development, and constructed the model with UML, designed the system and the quality assurance plan together with teammates; Developed front-end pages by Bootstrap and implemented the back-end systems by Python and Django, with MySQL being the database; Designed and realized testing with Scrapy and Selenium;

## 05/2017-05/2018 Student Research Training Program: Application of block-chain Technology to Supply Chain Finance

Duties: Studied block-chain technology and supplied chain finance; participated in writing patent, developing the workflow system based on block-chain technology and testing the performance of some bitcoin systems.

## 09/2017-01/2018 Computer Networks: Little Web Server

Duties: Realized the functions of Get and Post of HTTP protocol based on Socket Programming via C++

## Internship

### 09/2018-now NetEase Game Pangu Studio, Hangzhou Zhejiang China

Duties: Acquired distributed system knowledge, from ACID and CAP theory to PAXOS protocol; analyzed some systems like ZooKeeper and Tair. Designed and implemented matching algorithm and PVE level selection system.

## Extracurricular Activities

### 09/2015-06/2017 Assistant, the Bureau of Student Association Union, ZJU

Duties: Organized 4 activities, delivered daily work and communicated between the Bureau and cadres

### 09/2015-now Member, Student Drama Club, Wenqin Art Group, ZJU

Duties: Participated in drama performance 3 times, like *Pirate Dr. Faustus*, *In Memory of Chu Kochen*, *A Person Pined Alone* written by Bing Xin; worked as stage manager in *Art*.

### 07/2017-08/2017 Volunteer Leader, Voluntary Education Team Supported by ZJU and Local Government in Longquan

Duties: Arranged itinerary for 20 volunteer teachers; managed classes, teachers and courses and schedules; Communicated with local government for equipments and classrooms; Managed local pupils and taught them math.

### 09/2015-06/2016 Commissary in Charge of Sports, Class 1502 of Software Engineering, ZJU

Duties: Attended class basketball league matches and college football tournament.

### 04/2016 Volunteer, 2016 Zhejiang University Group Wedding, ZJU

## Other Information

Languages: C/C++, Python, Java, Lua, Swift, HTML.

OS: Linux (experimental environment), Mac OS (personal computer).

Tools: Gem5, Django, Bootstrap, Xcode, Unity, MySQL, Packet Tracer, Wireshark, Selenium, Qt.

Interests: Playing drama; playing saxophone & guitar; playing basketball & football; singing.

# Mem-Cloak: Practical Access Obfuscation for Untrusted Memory.

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## Abstract

Access patterns over untrusted memory have long been exploited to infer sensitive information like program types or even secret keys. Most existing obfuscation solutions hide real memory accesses among a sufficiently large number of dummy memory accesses. Such solutions lead to a heavy communication overhead and more often apply to the client/server scenario instead of the CPU/memory architecture. Sporadic obfuscation solutions strive for an affordable memory bandwidth cost at the expense of security degradation. For example, they may have to obfuscate accesses over a limited range of memory space to control the overhead. In this paper, we present MemCloak to obfuscate accesses throughout the entire memory space with an  $O(1)$  communication overhead. We advocate leveraging data redundancy to achieve extremely efficient obfuscation. Loading multiple duplicates of a data block in memory, MemCloak enables the CPU to fetch the same data by accessing different memory locations. This breaks the condition for snooping the access pattern. Moreover, we leverage data aggregation to improve memory utilization. It enables the CPU to fetch the same aggregated data block times from the same memory location but each time for a different data block therein. This further prohibits an attacker from correlating memory accesses. We propose a series of optimization techniques to compress the position that tracks memory layout. The optimized position map is hundreds of times smaller than the traditional position map. It takes only several megabytes for protecting a 4 GB memory and can fit in an on-chip cache or buffer. We implement MemCloak using the gem5 simulator and validate its performance using highly memory-intensive MiBench benchmarks.

## Reference

Weixin Liang, Kai Bu, Ke Li, Jinhong Li, and Arya Tavakoli. 2018. Mem-Cloak: Practical Access Obfuscation for Untrusted Memory. In 2018 Annual Computer Security Applications Conference (ACSAC '18), December 3–7, 2018, San Juan, PR, USA. ACM, New York, NY, USA, 11 pages.

# FauxBuster: A Content-free Fauxtography Detector Using Social Media Comments

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## Abstract

With the increasing popularity of online social media (e.g., Facebook, Twitter, Reddit), the detection of misleading content on social media has become a critical problem. This paper focuses on an important but

largely unsolved problem: detecting fauxtography (i.e., social media posts with misleading images). We found that the existing literature falls short in solving this problem. In particular, current solutions either focus on the detection of fake images or misinformed texts of a social media post. However, they cannot solve our problem because the detection of fauxtography depends not only on the truthfulness of the images and the texts but also on the information they deliver together on the posts. In this paper, we develop the FauxBuster, an end-to-end supervised learning scheme that can effectively track down fauxtography by exploring the valuable clues from user's comments of a post on social media. The FauxBuster is content-free in that it does not rely on the analysis of the actual content of the images, and hence is robust against sophisticated uploaders who can intentionally modify the description and presentation of the images. We evaluate FauxBuster on real world datasets collected from two mainstream social media platforms - Reddit and Twitter. The results show our scheme is both effective and efficient in addressing the fauxtography problem.

## Reference

Yue Zhang, Lanyu Shang, Biao Geng, Shuyue Lai, **Ke Li**, Hongmin Zhu, Md Tanvir Amin, Dong Wang, FauxBuster: A Content-free Fauxtography Detector Using Social Media Comments, Accepted by 2018 IEEE international Conference on Big Data.

THIS IS A PDF DOWNLOADED AND PRINTED BY THE TEST TAKER, INTENDED FOR THE TEST TAKER'S PERSONAL RECORDS.

**Name:** Li, Ke

Last (Family/Surname) Name, First (Given) Name Middle Name

**Email:** lovetoamtoboy@gmail.com**Gender:** M**Date of Birth:** 21 Apr 1997**Registration Number:** 0000 0000 3407 5864**Test Date:** 25 Aug 2018      **Sponsor Code:**

Li, Ke  
38 Zheda Rd., Xihu District  
Zhejiang University  
Hangzhou, Zhejiang 310027  
China

**Country of Birth:** China**Native Language:** CHINESE**Test Center:** APCN-1811 - South Bend - Mishawaka**Test Center Country:** United States**Inst. Code** | **Dept. Code****TOEFL iBT Scaled Scores**

Reading	.....	<b>28</b>
Listening	.....	<b>28</b>
Speaking	.....	<b>22</b>
Writing	.....	<b>28</b>
<b>Total Score</b>	.....	<b>106</b>

**ID Type:** Passport**ID No.:** xxxxxxxxxxxxxxxxxxxx7390**Issuing Country:** China

18

Reading Skills	Level	Your Performance
Reading	High	<p>Test takers who receive a score at the <b>HIGH level</b>, as you did, typically understand academic texts in English that require a wide range of reading abilities regardless of the difficulty of the texts.</p> <p>Test takers who score at the <b>HIGH level</b>, typically</p> <ul style="list-style-type: none"> <li>have a very good command of academic vocabulary and grammatical structure;</li> <li>can understand and connect information, make appropriate inferences, and synthesize ideas, even when the text is conceptually dense and the language is complex;</li> <li>can recognize the expository organization of a text and the role that specific information serves within the larger text, even when the text is conceptually dense; and</li> <li>can abstract major ideas from a text, even when the text is conceptually dense and contains complex language.</li> </ul>
<b>Listening Skills</b> <b>Level</b> <b>Your Performance</b>		
Listening	High	<p>Test takers who receive a score at the <b>HIGH level</b>, as you did, typically understand conversations and lectures in English that present a wide range of listening demands. These demands can include difficult vocabulary (uncommon terms, or colloquial or figurative language), complex grammatical structures, abstract or complex ideas, and/or making sense of unexpected or seemingly contradictory information.</p> <p>When listening to lectures and conversations like these, test takers at the <b>HIGH level</b> typically can</p> <ul style="list-style-type: none"> <li>understand main ideas and important details, whether they are stated or implied;</li> <li>distinguish more important ideas from less important ones;</li> <li>understand how information is being used (for example, to provide evidence for a claim or describe a step in a complex process);</li> <li>recognize how pieces of information are connected (for example, in a cause-and-effect relationship);</li> <li>understand many different ways that speakers use language for purposes other than to give information (for example, to emphasize a point, express agreement or disagreement, or convey intentions indirectly); and</li> <li>synthesize information, even when it is not presented in sequence, and make correct inferences on the basis of that information.</li> </ul>

Speaking Skills		Level*	Your Performance
Speaking about Familiar Topics		Fair	Your responses indicate you are able to speak in English about your personal experiences and opinions in a mostly clear and coherent manner. Your speech is mostly clear with only occasional errors. Grammar and vocabulary are somewhat limited and include some errors. At times, the limitations prevent you from elaborating fully on your ideas, but they do not seriously interfere with overall communication.
Speaking about Campus Situation		Fair	Your responses demonstrate an ability to speak in English about reading material and experiences typically encountered by university students. You are able to convey relevant information about conversations, newspaper articles, and campus bulletins; however, some details are missing or inaccurate. Limitations of grammar, vocabulary, and pronunciation at times cause difficulty for the listener. However, they do not seriously interfere with overall communication.
Speaking about Academic Course Content		Fair	Your responses demonstrate that you are able to speak in English about academic reading and lecture material, with only minor communication problems. For the most part, your speech is clear and easy to understand. However, some problems with pronunciation and intonation may occasionally cause difficulty for the listener. Your use of grammar and vocabulary is adequate to talk about the topics, but some ideas are not fully developed or are inaccurate.
Writing Skills		Level*	Your Performance
Writing based on Reading and Listening		Good	You responded well to the task, relating the lecture to the reading. Weaknesses, if you have any, might have to do with <ul style="list-style-type: none"> <li>• slight imprecision in your summary of some of the main points and/or</li> <li>• use of English that is occasionally ungrammatical or unclear.</li> </ul>
Writing based on Knowledge and Experience		Good	You responded with a well-organized and developed essay. Weaknesses, if you have any, might have to do with <ul style="list-style-type: none"> <li>• use of English that is occasionally ungrammatical, unclear, or unidiomatic and/or</li> <li>• elaboration of ideas or connection of ideas that could have been stronger.</li> </ul>

**THIS IS A PDF DOWNLOADED AND PRINTED BY THE TEST TAKER, INTENDED FOR THE TEST TAKER'S PERSONAL RECORDS.**

This score report provides four section scores and a total score. An analysis of your strengths and weaknesses in English is included. The level pertaining to each skill should not be generalized beyond the performance on this test. Skill levels and their associated descriptions are not intended for use by institutions as part of their admissions criteria and will not be shared unless you grant permission.

**Information About Scores:** The following scaled scores are reported for the TOEFL iBT test. A total score is not reported when one or more sections have not been administered. These scores have the following ranges:

Sections	Scaled Scores
Reading	0-30
Listening	0-30
Speaking	0-30
Writing	0-30
<b>Total Score</b>	0-120

**Score Legends:**

Reading Skills	
Level	Total Scaled Score Range
High	22-30
Intermediate	15-21
Low	0-14

Speaking Skills	
Level	Total Scaled Score Range
Good	26-30
Fair	18-25
Limited	10-17
Weak	0-9

Listening Skills	
Level	Total Scaled Score Range
High	22-30
Intermediate	14-21
Low	0-13

Writing Skills	
Level	Total Scaled Score Range
Good	24-30
Fair	17-23
Limited	1-16
Score of Zero	0

**Institution Codes:** The code numbers shown on page 1 of this report are the ones you selected before you took the test. If any institution code you selected is missing, it was incorrect and the TOEFL® Program was unable to send a score report to that institution.

DEPT.	WHERE THE REPORT WAS SENT
00	Admissions office for undergraduate study or an institution or agency that is not a college or university
01, 04-99	Admissions office for graduate study in a field other than management (business) or law according to the codes selected when you registered
02	Admissions office of a graduate school of management (business)
03	Admissions office of a graduate school of law

Additional information about TOEFL iBT scores can be found on the Test Takers section of the TOEFL website at [www.ets.org/toefl](http://www.ets.org/toefl).

\* Skill levels for speaking and writing individual skills are estimates of performance at the item level. The total writing and speaking scaled scores and ranges are more accurate. Therefore it is not appropriate to combine the individual skill levels. Doing so may lead to apparent inconsistencies between the diagnostic feedback and reported writing and speaking scores.

**IMPORTANT NOTE TO SCORE USERS:** This PDF score report was downloaded and printed by the test taker. It is not an Official Score Report sent by ETS directly to an organization designated by the test taker. If you find it necessary to verify the scores on this report, please contact the TOEFL Score Verification Service at +1-800-257-9547 or +1-609-771-7100. Scores more than two years old cannot be reported or validated.

KE LI

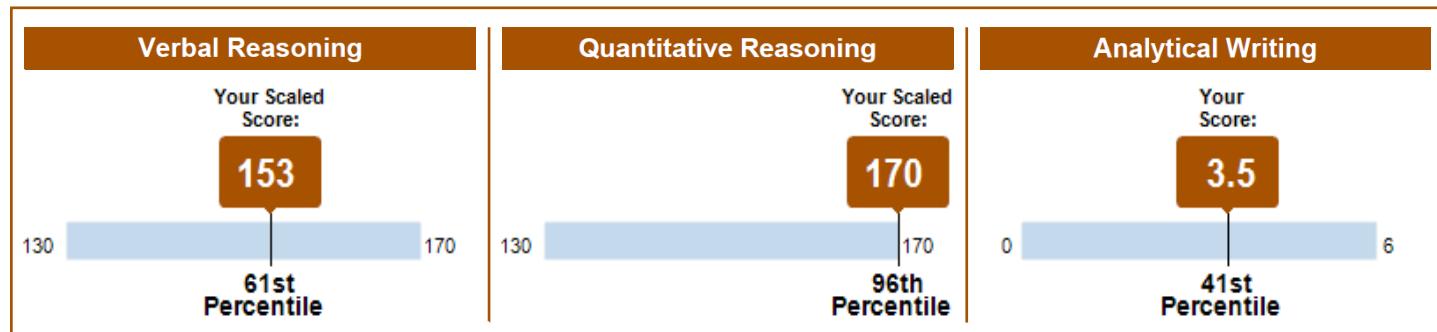
Most Recent Test Date: September 14, 2018

**Address:** 38 ZHEDA RD., XIHU DISTRICT, ZHEJIANG UNIVERSITY, HANGZHOU, Zhejiang, 310027 China

Registration Number: 3513986  
Print Date: October 29, 2018

**Email:** kli@zju.edu.cn**Phone:** 86-18867158066**Date of Birth:** April 21, 1997**Social Security Number (Last Four Digits):****Gender:** Male**Intended Graduate Major:** Computer Software Engineering (1206)

## Your Scores for the General Test Taken on September 14, 2018



## Your Test Score History

## General Test Scores

	Verbal Reasoning	Quantitative Reasoning	Analytical Writing			
Test Date	Scaled Score	Percentile	Scaled Score	Percentile	Score	Percentile
September 14, 2018	153	61	170	96	3.5	41
May 20, 2018	148	38	167	91	3.0	17

## Subject Test Scores

You do not have reportable test scores at this time.

## Your Score Recipient(s)

## Undergraduate Institution

Report Date	Institution (Code)	Department (Code)	Test Title	Test Date

## Designated Score Recipient(s)

Report Date	Score Recipient (Code)	Department (Code)	Test Title	Test Date
Pending	U PENN SCHL OF ENG APPL SCI ( 2888 )	COMPUTER/INFO SCIENCE-OTHER ( 0499 )	General Test	September 14, 2018

- **Pending** - Scores are being processed or are not yet reportable.

KE LI

Most Recent Test Date: September 14, 2018

Date of Birth: April 21, 1997

Registration Number: 3513986  
Print Date: October 29, 2018

## About Your GRE® Score Report

### Score Reporting Policies

With the *ScoreSelect®* option, you can decide which test scores to send to the institutions you designate. There are three options to choose from:

- Most Recent option – Send your scores from your most recent test administration
- All option – Send your scores from all administrations in the last five years
- Any option – Send your scores from one OR as many test administrations in the last five years (this option is not available on test day when you select up to four FREE score reports)

Scores for a test administration must be reported in their entirety. Institutions will receive score reports that show only the scores that you selected to send to them. There will be no special indication if you have taken additional GRE tests. See the *GRE® Information Bulletin* for details. The policies and procedures explained in the Bulletin for the current testing year supersede previous policies and procedures in previous bulletins.

Scores will be sent to designated score recipients approximately 10-15 days after a computer-delivered test and 5 weeks after a paper-delivered test. If your scores are not available for any reason, you will see "Not Available" in Your Test Score History.

GRE test scores are reportable according to the following policies:

- For tests taken prior to July 1, 2016, scores are reportable for five (5) years following the testing year in which you tested (July 1 – June 30). For example, scores for a test taken on May 15, 2015, are reportable through June 30, 2020. GRE scores earned prior to August 2011 are no longer reportable.
- For tests taken on or after July 1, 2016, scores are reportable for five (5) years following your test date. For example, scores for a test taken on July 3, 2016, are reportable through July 2, 2021.

Note: Score recipients will only receive scores from test administrations that you have selected to send to them.

### Percentile Rank (% Below)

A percentile rank for a test score indicates the percentage of test takers who took that test and received a lower score. Regardless of when the reported scores were earned, the percentile ranks for General Test and Subject Test scores are based on the scores of all test takers who tested within the most recent three-year period.

### Retaking a GRE Test

You can take the *GRE®* General Test *once every 21 days*, up to *five times* within any continuous rolling 12-month period (365 days). This applies even if you canceled your scores on a test taken previously. You can take the paper-delivered GRE General Test and *GRE®* Subject Tests as often as they are offered.

Note: This policy will be enforced even if a violation is not immediately identified (e.g., inconsistent registration information) and test scores have been reported. In such cases, the invalid scores will be canceled and score recipients will be notified of the cancellation. Test fees will be forfeited.

### For More Information

For information about interpreting your scores, see *Interpreting Your GRE Scores* at [www.ets.org/gre/understand](http://www.ets.org/gre/understand).

For detailed information about your performance on the Verbal Reasoning and Quantitative Reasoning sections of the computer-delivered GRE General Test, access the free GRE Diagnostic Service from your ETS account. This service includes a description of the types of questions you answered right and wrong, the difficulty level of each question, and the time spent on each question. This service is available approximately 15 days after your test administration and for six months following your test administration.

If you have any questions concerning your score report, email GRE Services at [gre-info@ets.org](mailto:gre-info@ets.org) or call 1-609-771-7670 or 1-866-473-4373 (toll free for test takers in the U.S., U.S. Territories and Canada) between 8 a.m. and 7:45 p.m. (New York Time).

# Northwestern | THE GRADUATE SCHOOL

## Recommendation Form

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The Graduate School Northwestern University Evanston, IL 60208-1113

Applicant Name: **Ke Li**

Program: **Computer Science: MS**

Applicant Waived Rights\*: **This applicant has waived the right to view their recommendation.**

Recommender Name: **Kai Bu**

Organization Name: **Zhejiang University**

Title: **Assistant Professor**

E-mail Address: **kaibu@zju.edu.cn**

Telephone Number: **+8618258816862**

Relationship to Applicant: **Supervisor and Student**

Certification (Date): **11-22-2018**

\*“Public Law 93-380, Educational Amendments Act of 1974, grants students the right to have access to letters of recommendation in their placement files. By selecting the "Waive access" option you are waiving access to these letters.”



Room 503, Zetong Building  
College of Computer Science and Technology  
Zhejiang University  
No. 38 Zheda Road, Hangzhou 310027, China  
November 05, 2018

Dear Graduate Admission Committee,

It is my great pleasure to strongly recommend Mr. Ke Li for admission to your university as a graduate student. I am an Assistant Professor in the College of Computer Science and Technology at Zhejiang University. I know Ke since he attended my course of Computer Architecture in the 2017 Fall-Winter semester. He earned an excellent grade of 93/100 and, as the third author, published a course-related research paper, MemCloak: Practical Access Obfuscation for Untrusted Memory (<http://list.zju.edu.cn/kaibu/memcloak.pdf>), in the Annual Computer Security Applications Conference (ACSAC) 2018. ACSAC is a well-known conference in the area of security. The acceptance rate of ACSAC 2018 is  $60/299 = 20.1\%$ . The accepted papers come also from top universities/institutions such as Princeton University, Georgia Institute of Technology, Purdue University, MIT Lincoln Laboratory, IBM Research, and Facebook. Throughout the entire process of course learning and research collaboration, I am deeply impressed by Ke's demonstration of smartness, creativeness, and collaborativeness in an intelligent and humble way. I believe further education abroad would offer him more advanced research practice and greater career opportunities.

Ke is the main reason why I was motivated to embark on computer architecture research. Although I have taught Computer Architecture for years, my main research interests lie in networking and security. As I continue to teach Computer Architecture each year, I cannot simply tell students that I teach this course, but my important research is elsewhere. I hesitated now and then to work on architecture research and hoped that would, in turn, strengthen my teaching skills. Ke is the very first student that accepted the challenge with me. We started with a project about memory security. The goal is to protect memory access patterns in a practically efficient way. Access patterns over memory have long been exploited to infer sensitive information like program types or even secrete keys. Most existing obfuscation solutions hide real memory accesses among a sufficiently large number of dummy memory accesses. Such solutions lead to a heavy communication overhead and more often apply to the client/server scenario instead of the CPU/memory architecture. Toward finding a practically efficient solution, Ke kept amazing me with his abilities of correlative learning and critical thinking. Computer architecture requires quite a bit of prerequisite knowledge like computer organization, assemble language, and operating system. Ke is really good at connecting new knowledge to what he already learned, and thus capable of dissecting complex questions. This demonstrates also his analytical ability. Some of his fresh perspectives of understanding the research problem highly contribute to our project progress. After months of collaboration, we designed and prototyped a data redundancy based solution that obfuscates memory accesses with only  $O(1)$  communication overhead. The paper has been accepted to ACSAC 2018. I envision Ke, after graduate training, with what it takes to design new algorithms or products.

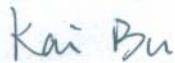
As a student in software engineering, Ke has also cultivated strong programming skills. To prototype our memory access obfuscation solution, we need to modify the gem5 simulator, which is a modular platform for computer-system architecture research. Due to the lack of

documentation and tutorial, Ke's capability of program analysis really helped us to understand how gem5 worked and to integrate our solution into gem5. Given that gem5 executes in an asynchronous fashion, it would have been a much more challenging task without having Ke in the team. He constantly demonstrated his proficiency in leading programming languages like Python and C++, and capability of debugging and troubleshooting programs. This makes me believe that he not only has the potential to innovate but also has the skills to implement.

Besides his academic potential, I and other students also enjoy having Ke in our team because of his collaborativeness. He has a great personality, always gently and humbly smiling while discussions. His occasional humor makes our discussions more cheerful and joyful. As he became more familiar with the gem5 code base, he coordinated the prototype task. Specifically, he modularized the implementation of our solution on gem5 and divided the task among several other teammates. Furthermore, we had another Canadian undergraduate student, Arya Tavakoli, from Simon Fraser University in our team. Ke was also responsible for teaming up with Arya on implementation. This further demonstrated Ke's English communication proficiency. He managed to lead them toward implementing the prototype. Such capability of coordination and communication would be a great asset for a future graduate student and a project leader alike senior position.

In summary, Ke is an extraordinary student with a solid professional background and a constant desire to learn and improve. I believe that Ke's enthusiasm for computer science and unremitting efforts will make him continue to succeed in his graduate study, and make more progresses in his academic pursuit and career development after graduation from your university. I sincerely thank you for evaluating his candidacy. If you have any further questions or require any further information, I would be more than happy to be of assistance.

Sincerely,



Kai Bu, Assistant Professor  
College of Computer Science and Technology  
Zhejiang University  
[kaibu@zju.edu.cn](mailto:kaibu@zju.edu.cn)  
+86-18258816862

## Recommendation Form

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The Graduate School Northwestern University Evanston, IL 60208-1113

Applicant Name: **Ke Li**

Program: **Computer Science: MS**

Applicant Waived Rights\*: **This applicant has waived the right to view their recommendation.**

Recommender Name: **Dong Wang**

Organization Name: **University of Notre Dame**

Title: **Assistant Professor**

E-mail Address: **dwang5@nd.edu**

Telephone Number: **+1-574-631-3749**

Relationship to Applicant: **Summer Internship Advisor**

Certification (Date): **11-30-2018**

\*“Public Law 93-380, Educational Amendments Act of 1974, grants students the right to have access to letters of recommendation in their placement files. By selecting the "Waive access" option you are waiving access to these letters.”



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## Department of Computer Science and Engineering

214 B Cushing Hall

Tel (574) 631-3749

Notre Dame, Indiana  
*dwang5@nd.edu*

Dong Wang

*email:*

46556 USA

Assistant Professor

Nov. 30, 2018

Dear Admission Committee,

I'm writing this letter to recommend Mr. Ke Li for admission to your graduate program. Ke has been working as an undergraduate researcher in our lab for the 8 weeks in summer 2018.

Ke contributes to our research project "Crowdsourcing-based Hateful Speech Detection in Live Video Streams". In this project, Ke and the team were dedicated to developing a novel tool to accurately detect nasty speech in major video streaming platforms such as YouTube and Twitch. The tool we developed has shown great potential in providing a peaceful environment to live video audiences.

I recommend Ke to be considered for your graduate program. Please do not hesitate to contact me if you need more details about Hongmin.

Sincerely,

*Dong Wang*

Dong Wang, Ph.D.  
Assistant Professor  
Department of Computer Science and Engineering  
214-B Cushing  
University of Notre Dame  
Tel: 574-631-3749, E-mail: dwang5@nd.edu

## Recommendation Form

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The Graduate School Northwestern University Evanston, IL 60208-1113

Applicant Name: **Ke Li**

Program: **Computer Science: MS**

Applicant Waived Rights\*: **This applicant has waived the right to view their recommendation.**

Recommender Name: **Tianlei Hu**

Organization Name: **Zhejiang University**

Title: **Associate Professor**

E-mail Address: **htl@zju.edu.cn**

Telephone Number: **+8613958091761**

Relationship to Applicant: **Teacher & Advisor**

Certification (Date): **12-03-2018**

\*“Public Law 93-380, Educational Amendments Act of 1974, grants students the right to have access to letters of recommendation in their placement files. By selecting the "Waive access" option you are waiving access to these letters.”



Tianlei Hu,  
Associate Professor and Master's Supervisor, Zhejiang University  
Director of NetEase Pangu Studio  
① +86-13958091761  
✉ [htl@zju.edu.cn](mailto:htl@zju.edu.cn)

Dear Sir or Madam,

This letter is written to offer my vigorous endorsement of Ke Li's application for his master's degree. I am an Associate Professor and Master's Supervisor in the College of Computer Science and Technology at Zhejiang University. Ke Li was a student in my course Secure Programming Techniques in May 2018. Also, I have been supervising his internship at NetEase Pangu Studio and instructing his graduation project of Transaction Management in Distributed Game Server since September 2018. Through the process, I acknowledge that, with his abilities in study and teamwork, Ke is both a good computer student and potential great software engineer. Without doubts, he will achieve a brilliant career if he gets a further education abroad.

As a professor, I was impressed by Ke Li's strong learning ability and good information sharing awareness. At the class, Ke Li could absorb secure programming techniques well to accomplish programming experiments, which won him a high score, 92 points. During the internship, he confidently shared knowledge about transaction management and the consistency protocol of distributed system (CAP, PAXOS, and ZAB, etc.), as well as two distributed systems examples (ZooKeeper and Tair), with clear knowledge structure graph and vivid metaphor expressions, to other software engineers in his technical group. All these hints reveal that he must have spent much time trying to simplify the knowledge based on his deep comprehension, making it easier for listeners to understand. This is a valuable skill for a software engineer and Ke has already mastered it at a good level.

As the director of Pangu Studio, I also found Ke's performance in server development during the internship surprising. Spending time communicating with both programmers and game planners, Ke got a clear view of the work process of game development. Also, through this effective communication, he could efficiently develop server-side application according to the requirements from the planners, and timely informed the client programmers and server programmers of his work and need of cooperation, since server development is not an independent work. In my opinion, a good student should master capable communication skill, but outstanding students, other than that, should think out of the box and Ke is just such a student. When Ke had server development tasks, he could jump out of his job and made it clear that how the tasks work with the cooperation from other groups. With this communication skills, the cooperation can always process without misunderstandings. What's more, Ke could also make plans based on the process of the whole project, divide requirements by importance to match the version

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update time. All these things make me believe that Ke is good at communication and has the ability to make considerations for the whole project not only his own jobs, which are essential for being a good software engineer.

Having seen the achievements and improvements of Ke Li from the class to internship, I believe he will make greater achievement in his future study and career through the graduate study at your esteemed university. Hence, I give my full support to his application. Your favorable consideration is greatly appreciated. If you want to know more about this student, please feel free to contact me.

Best Regards,  
Tianlei Hu