无人驾驶-未来交通与仿真研究

吴建平 教授
清华大学-剑桥大学-麻省理工学院“未来交通”研究中心主任

内容

- 无人驾驶的麦肯锡预测与中国发展趋势
- 未来交通（无人驾驶+共享交通）与颠覆性城市变革
- 无人驾驶的进程与挑战
- 无人驾驶仿真研究

无人驾驶的麦肯锡预测与中国发展趋势

- 全世界的汽车厂都在研究无人驾驶汽车
- 麦肯锡预测：
  - 在接下来的5年中，会出现SAE Level 4级别的无人驾驶
  - 在接下来的10年中，会出现SAE Level 5级别的无人驾驶

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

The table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BASt) and approximately correspond to those described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/deceleration	Monitoring of driving environment	Fallback performance of *dynamic driving task*	System capability (*driving modes*)	BASt level	NHTSA level
***Human driver* monitors the driving environment**								
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	System	Human driver	Human driver	Some driving modes	Partially automated	2
***Automated driving system* ("system") monitors the driving environment**								
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task* with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	System	Human driver	Some driving modes	Highly automated	3
4	High Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	System	Some driving modes	Fully automated	3/4
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	All driving modes	-	

无人驾驶与未来交通

无人驾驶的全面实现，将给未来的社会带来全新的景象

1. 道路通行能力将提高3-5倍（宽度减少，密度增加），或许路上不再拥堵
2. 极大提升道路交通的安全性，减少道路事故（70%）以上

未来交通与未来城市

无人驾驶+共享交通时代，人们不再买车

1. 将节省大量的汽车材料
2. 家庭不再有停车场，城市也不需要这么多的停车场，节约大量宝贵城市土地资源
3. 汽车厂将开始成为全产业链的共享交通服务商
4. ……

无人驾驶的技术路线

1. 无人驾驶汽车像人类驾驶员一样感知和决策，但是比人类驾驶员有更快的反应能力和更精确定位能力，同时具有很强的系统安全性。缺点：没有联网时，不知道远距离发生的事件（比如事故、积水……）！
2. 通过车联网技术进行车与车、车与基础设施的信息交换，替代无人驾驶汽车的一部分感知能力（例如：网联汽车的位置和速度信息、控制中心的导航信息等）。缺点：要求所有汽车（含有人与无人驾驶）全部联网才能实现基于车联网的无人驾驶。同时，不能感知各种（没有联网的）障碍物！
3. 未来最佳的技术路线是两种技术融合，实现最大的效率与安全

无人驾驶的进程与挑战

- 从全部人类驾驶到全部无人驾驶有一个较长的混行时期（部分有人、部分无人、部分网联）
- 关键难题：混行互动，如：
  - 无人驾驶 跟随有人驾驶
  - 有人驾驶 跟随无人驾驶
- 未来交通时代（混行与全无人）的安全与效率博弈

无人驾驶汽车测试与研究

1. 闭门测试（测试场单车测试）
2. 蛮力测试（让无人驾驶汽车在实际道路网上行驶数百万英里）（10年时间，几百人的事故代价）
3. 测试场综合测试（美国（2017-03），3000多亩地，综合测试）（减少测试里程30%）
4. 交通仿真+测试场联合测试（减少测试里程50%，节省测试时间50%）（清华大学（2017-05）、欧盟（2017-07））

清华大学-XXXX未来交通系统研究院（筹）目标与任务

- 研究与建设无人驾驶系统仿真平台
- 研究与设计实体标准化测试场
- 设计未来交通大数据中心和云计算平台
- 研究无人驾驶车技术和标准，制定未来交通控制技术标准与法律、法规
- 研究和打造标准化测试流程以及无人驾驶汽车“进路许可”国家测试中心
- 推动清华大学无人驾驶（智能汽车）和未来交通技术转移，规划和建设无人驾驶汽车的产业链体系，成为世界未来交通产业的引领者

无人驾驶未来交通模拟仿真研究

关于 FLOWSIM 模型：

- 基于模糊数学的道路交通仿真模型

  Fuzzy LOgic based roadWay traffic SImulation Model

特点：

1. 一个基于道路交通参与者个体行为的交通仿真模型

   A individual road user behavior based traffic simulation model

2. 系统里每辆车产生时，可以赋予它特定的行为特性模块

   Each individual vehicle can be assigned with specific behavior model when generated in the system

无人驾驶未来交通模拟仿真研究

Tsinghua University

FLOWSIM 与无人驾驶车辆仿真：

- 无人驾驶汽车的跟车特性

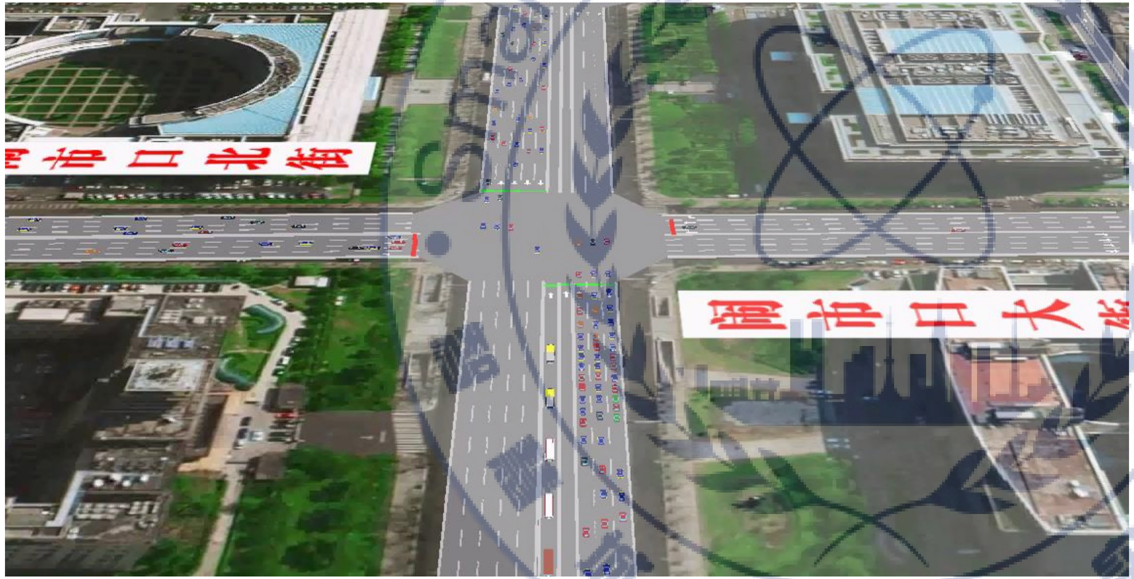
  The car following model for autonomous driving

- 无人驾驶汽车的换道特性

  The lane changing model for autonomous driving

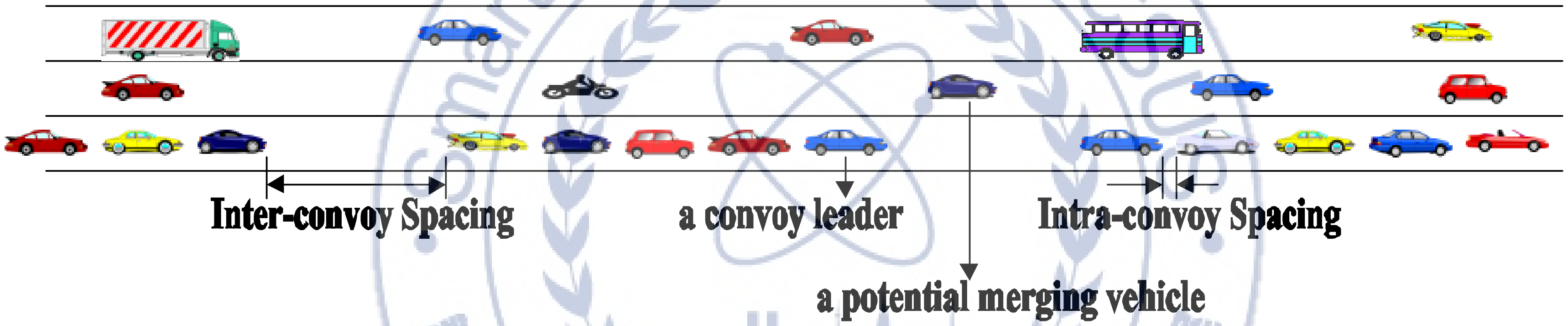
清华大学-XXXX未来交通系统研究院（筹）

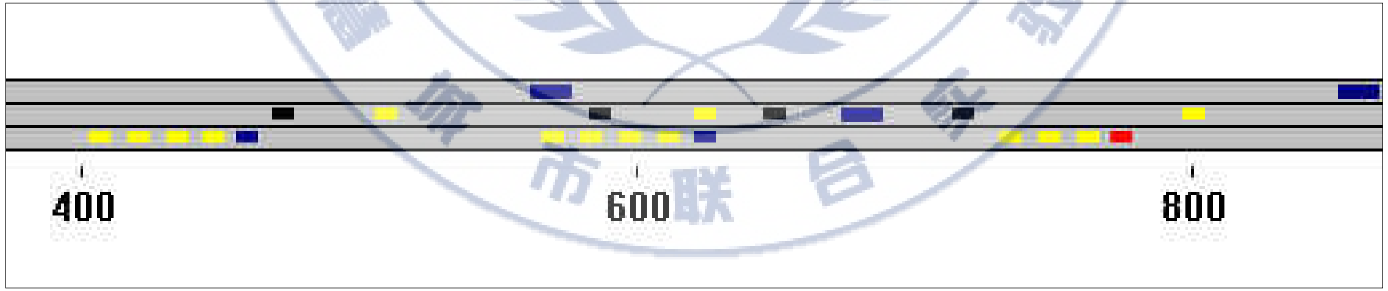
无人驾驶未来交通系统仿真研究 （FLOWSIM）



FLOWSIM 无人驾驶未来交通模拟仿真研究

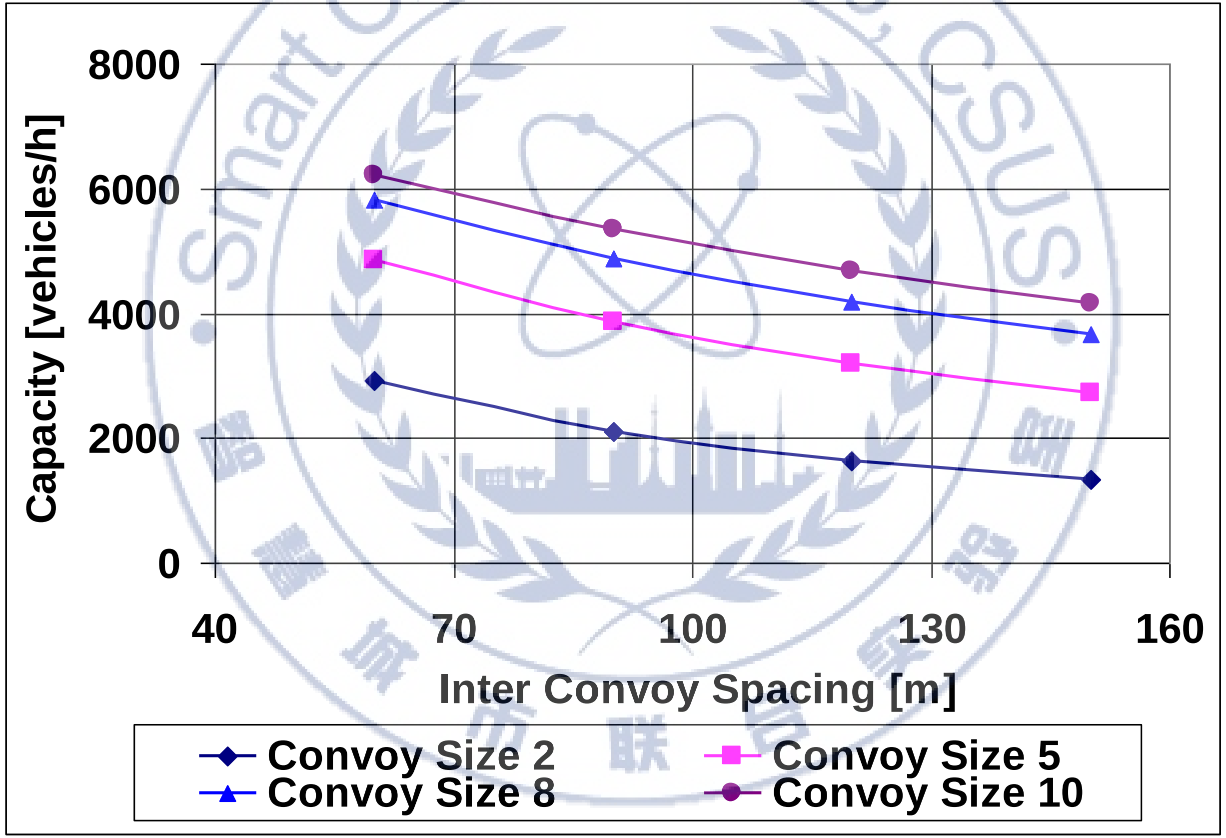
（队列行驶）





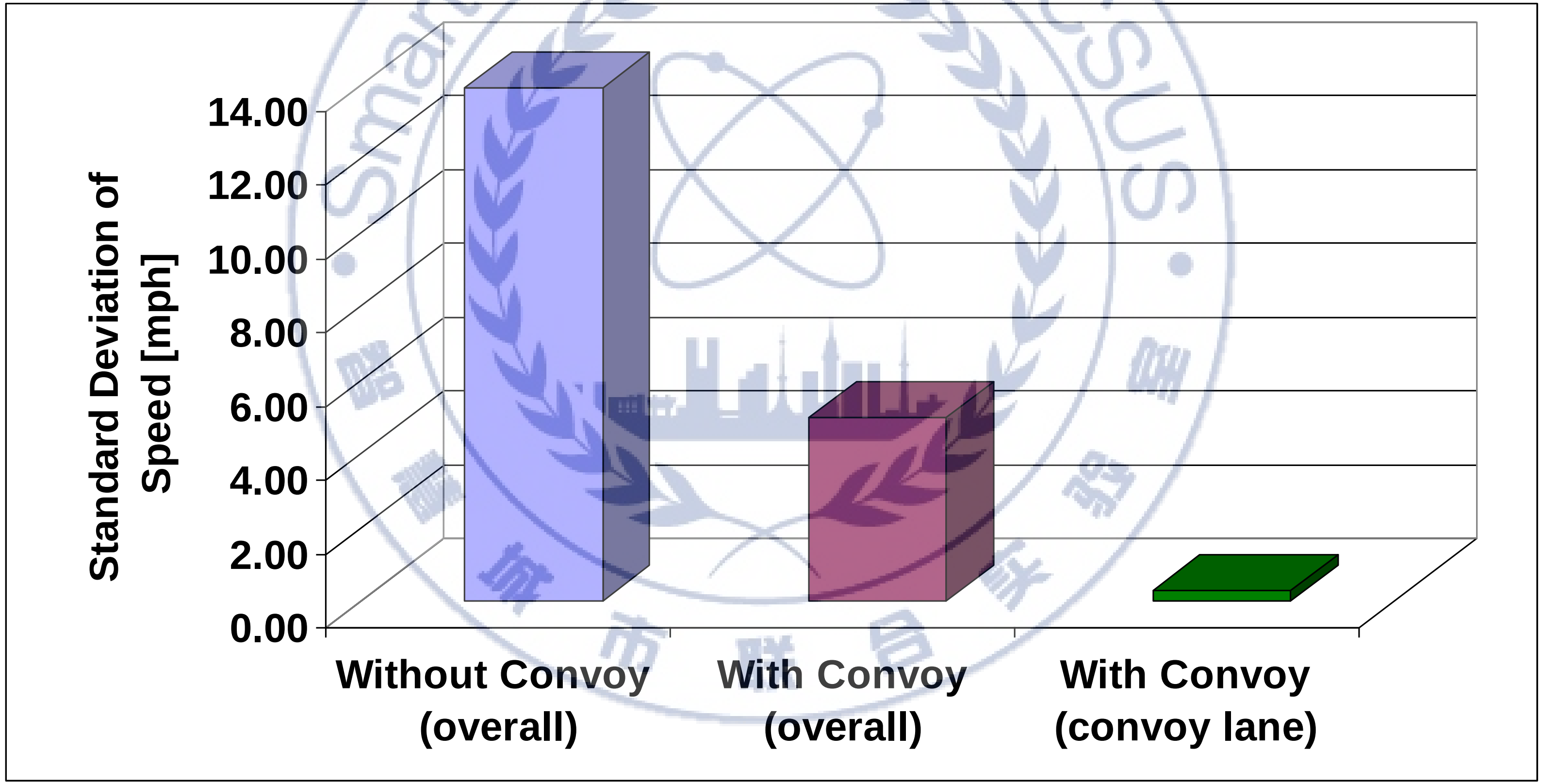
FLOWSIM 通行能力影响分析

(无人驾驶队列行驶)

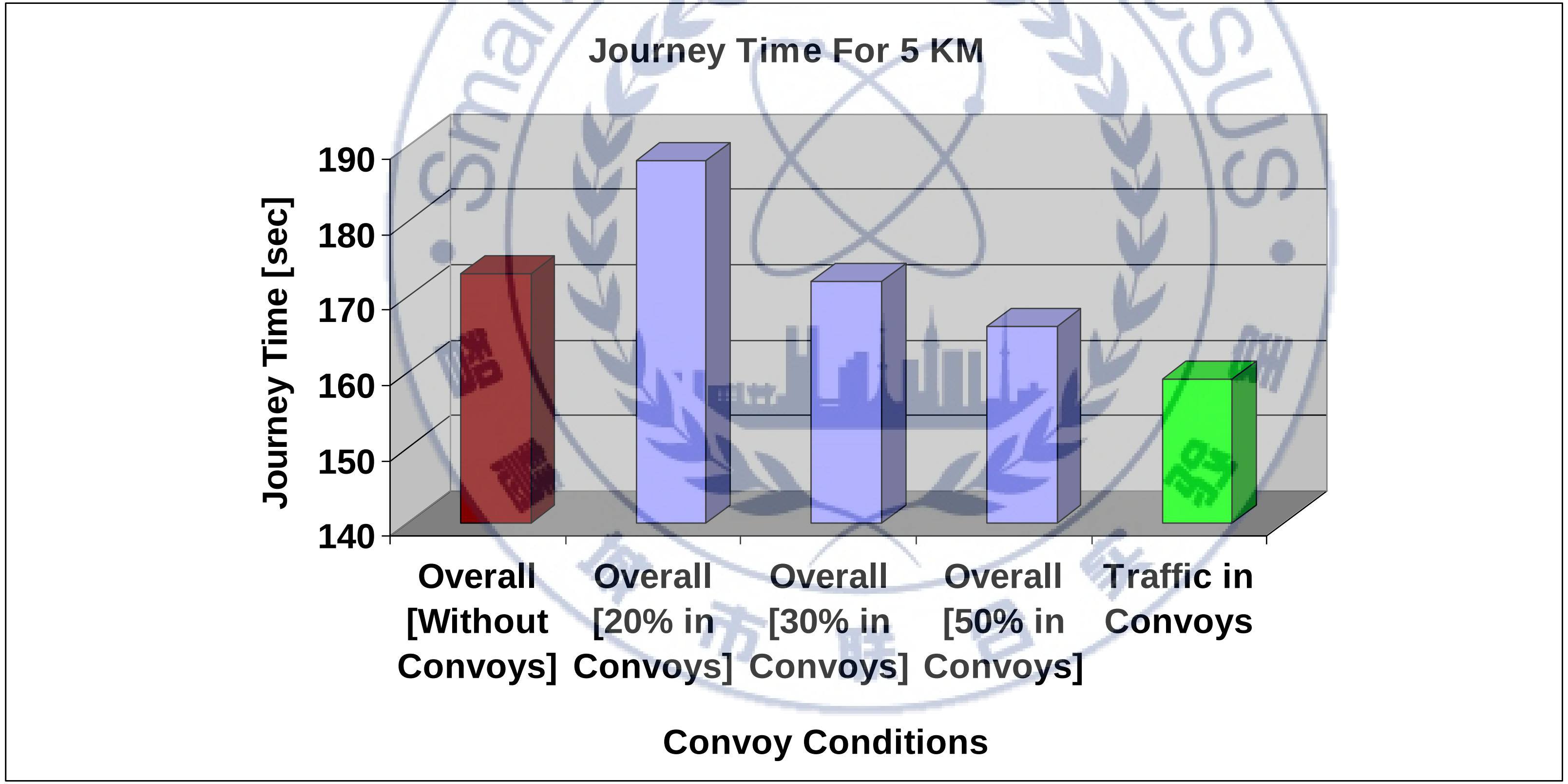


Convoy Speed=70 mph, and Intra-convoy Spacing=9 meters.

车流稳定性影响分析（无人驾驶队列行驶）



旅行时间影响分析（无人驾驶队列行驶）



THE IMPACTS OF CONVOYS ON MOTORWAY TRAFFIC

J. WU, M. MCDONALD AND M. BRACKSTONE
Department of Civil and Environmental Engineering,
University of Southampton, Southampton, SO17 1BJ, the UK

Abstract

The idea of convoy operation, a new strategy of Automated Highway System (AHS) for motorway traffic is presented. The paper focus to the investigation of the potential impacts of convoy operations on motorway traffic in four aspects: i) flow stability, ii) capacity, iii) journey time, and iv) efficiency of merge and de-merge, by simulation study using FLOWSIM model.

Simulation results shown that convoy operation can significantly improve motorway traffic on flow stability, and increase motorway capacity by more efficient use of convoy lane. Convoy operation also significantly reduces journey time for traffic in convoy lane. However, the benefit on journey time for traffic overall happens only when the convoying traffic is over 30% of total motorway traffic. The merge and de-merge has been found to be difficult when demand and percentage convoy equipped traffic are high. Further study is needed to find alternative supporting measures to reduce merge and de-merge time before convoys can be implemented.

Keywords: Automated Highway System, Convoy Operation, Motorway, FLOWSIM, Simulation, Flow Stability, Capacity, Journey Time, Merge, De-merge.

谢谢！

吴建平教授

- 联系方式：
  - Email: jianpingwu@tsinghua.edu.cn
  - 电话：010 62797229