

# 做“接地气”的高水平科研

从实践中来、到实践中去

裴丹

2016.09.06

# 概览

- \* 个人简介
- \* 导师、学生互相的期待
- \* 科研经验分享
- \* 论文写作经验分享

# 个人简介

- \* 清华大学本科、硕士。2005年加州大学洛杉矶分校 (UCLA) 计算机博士，并获当年计算机系唯一的最佳博士学位论文奖
- \* 2005年加入美国AT&T研究院 (AT&T Labs – Research) 任资深研究员 (Senior Member of Technical Staff – Research) 和主任研究员 (Principal Member of Technical Staff – Research)
- \* 2011年获ACM Senior Member 和 IEEE Senior Member
- \* 2012年获得中组部千人计划青年项目荣誉，并于年底加入计算机系任教
- \* 973, 863, 国家自然科学基金的资助；与百度、MSRA、中石油合作
- \* 在美国期间执导过CMU, Cornell, Princeton, UCLA, GaTech, Michigan, Northwestern 等大学的博士生，毕业之后在 MSR, AT&T Research, Google, IBM Research, Bell Labs, Columbia, Ohio State, Northeastern, HKUST 担任科研职位。

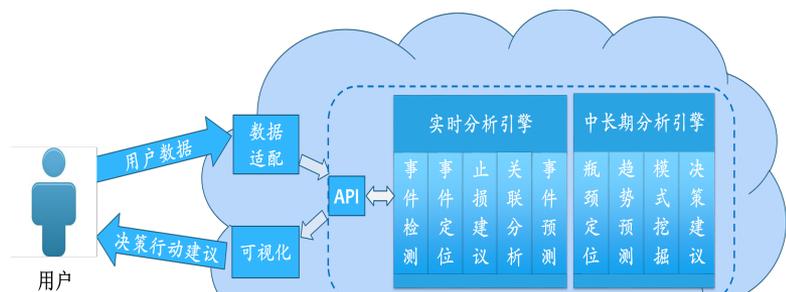
# 研究方向:

## 基于机器学习手段, 管理网络及应用的性能和安全

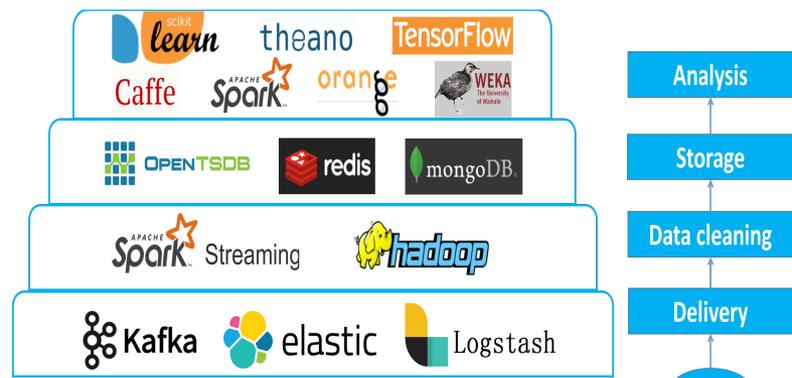
**RobOP: 互联网应用管理助手机器人**

**SmoothApp: 管理移动应用性能的统一架构**

**WiFi Union: 优化WiFi性能体验, 解决安全、隐私问题**



**AppMind: 一个运行在云服务器中的机器学习平台, 支持 OpeRobot, SmoothApp 和WiFi Union的海量数据处理**



**Cake: 一个大数据处理系统, 结合开源的计算平台, 使得机器学习实验易如反掌**

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# 博士生应具备的基本素质

- \* 科研态度积极主动, 要push
- \* 勤谨用功
- \* 心态阳光
- \* 沟通能力良好, 逻辑清晰
- \* 编程能力较强
- \* 中英文写作良好、逻辑性强

# 如何积极主动？

- \* 及时回复导师的邮件、信息
- \* 定期给导师发工作总结
- \* 主动要求讨论
- \* 主动报名在组会作报告
- \* 自己主动写文档，写论文

# 珍惜导师的时间

THE GREATEST GIFT YOU  
CAN GIVE SOMEONE  
IS YOUR  
**TIME.**  
BECAUSE WHEN YOU  
GIVE YOUR TIME,  
YOU ARE GIVING A  
PORTION OF YOUR LIFE  
THAT YOU WILL NEVER  
GET BACK.

# 关于当面讨论

- \* 学生负责提出清晰的议题
- \* 学生负责整理好讨论所需材料，充分利用会议时间
- \* 展示的结果要想好解释，讨论言简意赅，抓住关键
- \* 向老师提出的问题不应是填空题，而应该是选择题，并且给出了自己建议的答案及原因
- \* 讨论之后写会议记录
- \* 每次会议不断更新讨论材料，会对论文写作有很大的帮助

# 对博士生培养的理解

- \* “传道”：训练学生独立自主科研的能力。这包括一系列方法论：独立寻找科研方向，初步定义科研问题，实施过程中调整研究手段并调整科研问题的定义，最终完成科研成果。
- \* “授业”：在一个博士生读博期间所钻研的具体科研方向上，传授给学生具体的知识并教会学生自己独立获取科研所需知识，从而使得学生在自己的科研方向上成为领域专家，为学生后续的就业打好坚实的基础。
- \* “解惑”：针对学生在科研过程中产生的思想动摇和困惑，给予及时的支持、帮助和解答。（推荐阅读：施一公讲话稿）

# Recommended Reading (more on my course website

<http://netman.cs.tsinghua.edu.cn/~peidan/ANM> )

- \* **“How to Have a Bad Career in Research/Academia”.**  
**by “Professor David A. Patterson”**
- \* “How to Increase the Chances Your Paper is Accepted at ACM SIGCOMM”. by *Craig Partridge*
- \* “Thinking outside the box”. By Michael J. Neely
- \* “How to Do Great Research”. By Nick Feamster and Alex Gray

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# What's good research?

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

## 接地气：从实践中来、到实践中去

- \* 从实际网络及服务系统中发现、抽象、提炼、解决科研课题
  - 》 问题和解决方案具有开创性
- \* 寻找并采用交叉领域的一些关键技术
  - 》 在一些关键科研挑战上取得具有创新性和突破性的进展
- \* 强调实际系统搭建和可部署
  - 》 科研成果在实践中得到应用和转化

# 从实践中寻找科研方向

有好的立意，论文就成功了一半

# It's important to read research papers

- \* Purpose: background knowledge, algorithm, methodology, writing, principle, solution inspiration, evaluation methodology for the problem you are working on
  - \* Help you know more about your field than your advisor
- \* However, here is my strongly biased personal opinion:
  - \* Papers are not for finding topics for your next great paper.

# Strategy 1: Discover and define real world problems to work on

- \* A research that addresses an unsolved problem will have much higher chance to have impact and get recognized.
- \* Discover and define the important but unsolved problems from the real-world.

# How?

- \* Why we had endless problems to work on at AT&T Research:
  - \* Work with network operators and planners everyday so we know their pains
  - \* Do intensive interviews with operators in new business
- \* Academia: actively look for and create opportunities to get to know the real-world industry problems.
  - attend industry forums
  - talk to industry people;
  - industry intern and collaboration;
- \* Notice the pains around yourselves.

# 举例：在工业界论文做一次接地气的报可以吸引很多潜在合作者

- 覆盖范围大
- 直接接触到最相关的人, 了解最一线的问题
- 适宜网上传播



# Project Ideas due to my own Pains

- \* WiFi Union
- \* SmoothApp
- \* Experimental Platform for Applied Machine Learning

# WiFi Union

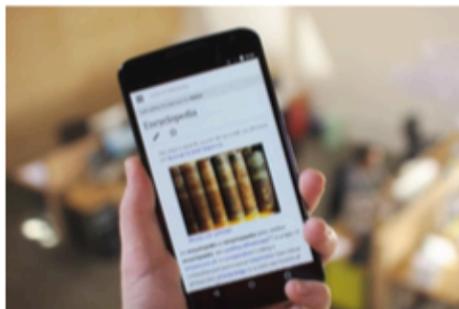
## 千万台家用和企业无线路由器协同共享无线频谱

973子课题“网络复杂行为的博弈决策机制与理论”2013CB329105,  
自然科学基金“基于用户需求的自治无线网络协作模型及优化方法研究”61472210  
校内拔尖人才项目“自治无线网络协作系统体系结构研究”  
自然科学基金重点“智能电网信息传输理论研究”61233007

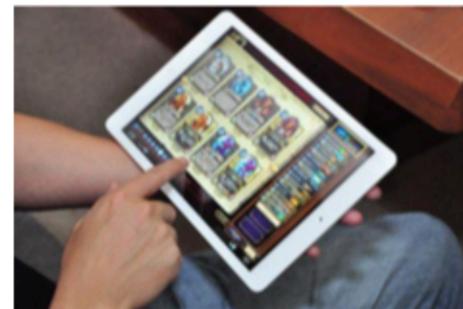
Real-time and interactive mobile applications requires low **latency**



Instant messaging



Web browsing



Online gaming

# Latency of mobile devices



WiFi latency is often unpredictable and occasionally high



<http://netman.cs.tsinghua.edu.cn/people/kaixin-sui/wifiseer-video/>

## Questions

How is WiFi latency?

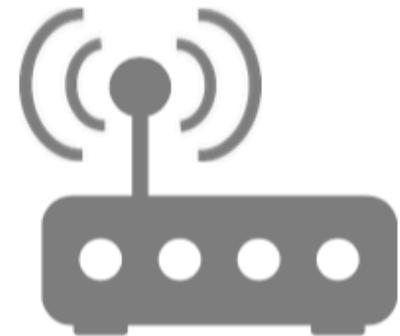


Mobile device

How related factors impact WiFi latency?

←..... WiFi latency .....→

How to improve WiFi latency?



Access point

**WiFi hop latency can be a key bottleneck for latency-sensitive applications.**



> 1.5 Million Apps

> 300,000 Developers





# There's an App For That

But its slow



★☆☆☆☆

"... Too slow - killing the usefulness when you really need to go."



“So slow. Did an intern write this app??”



“Slower than a snail.”



“Slow and unresponsive like mud”



“Sluggish and freezes my HTC phone.”



“Very very slow compared to even browsing web.”



“Consistently 3 seconds behind where I touch.”



“Loading GPS data is \*\*\* slow”



“So slow. Did an intern write this app??”



“Slower than a snail”

- \* Diverse environmental conditions
  - \* Network connectivity, GPS signal quality, etc
- \* Variety of hardware and OS versions
- \* Wide range of user interactions

Hard to emulate in the lab



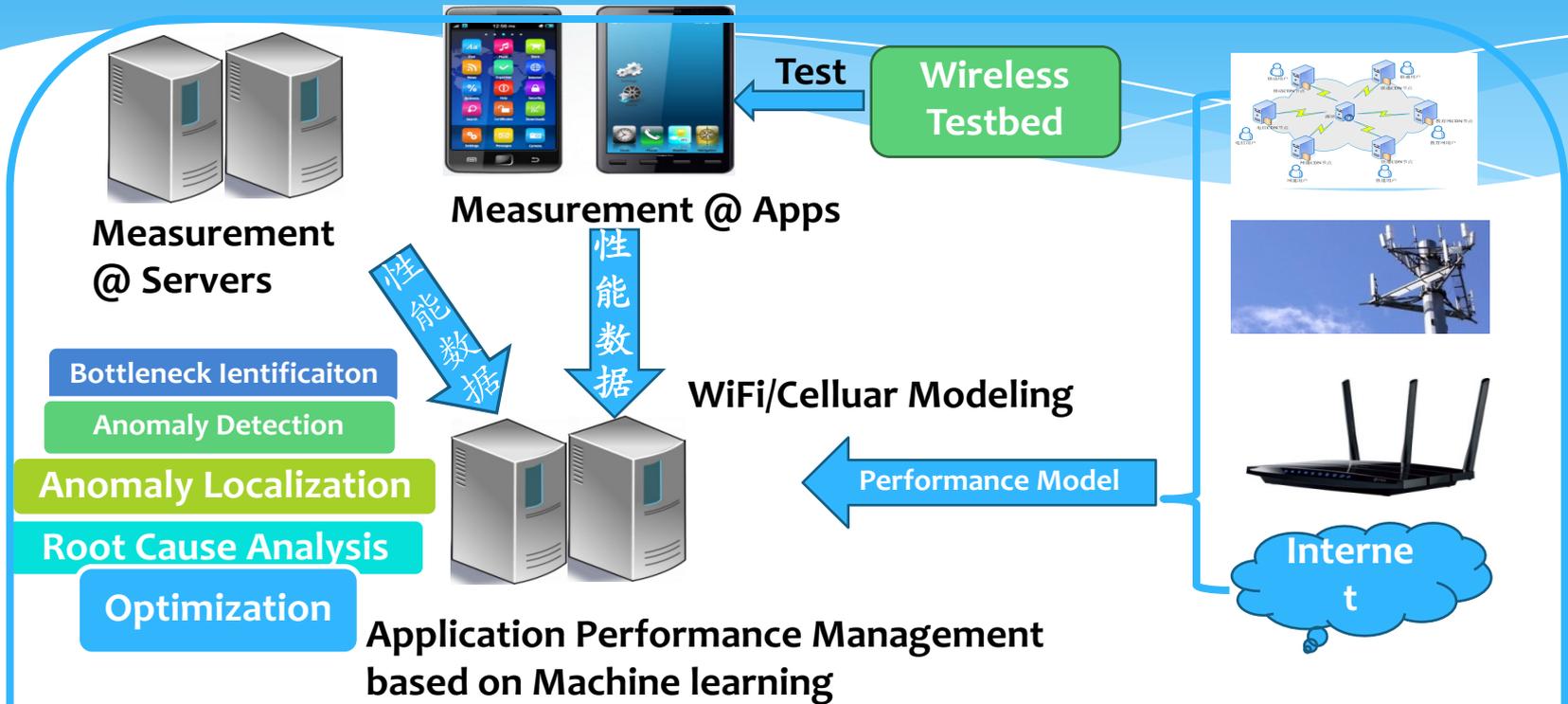
“Consistently 3 seconds pending where I touch.”



“... \*\*\* slow”

Performance problems are **inevitable in the wild**

# Monitoring and Analyzing Per-user Performance in the Wild



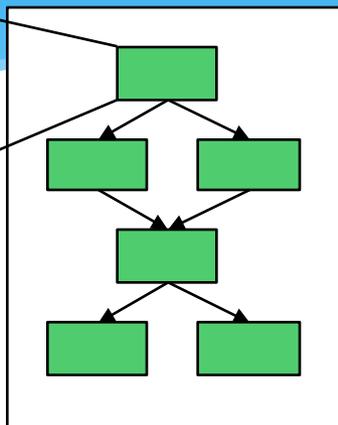
**SmoothApp: an architecture for managing mobile App performance**



# 面向网络数据的机器学习实验平台

模块

- 输入文件/值
- 输出文件/值



模块的输入输出相连  
构成实验



用户通过浏览器  
界面设计实验

实验控制器

- 按照先后顺序依次执行实验中的每一个模块。
- 若模块是确定性的，使用以往的运行结果。

平台运行队列

- Yarn
- ...

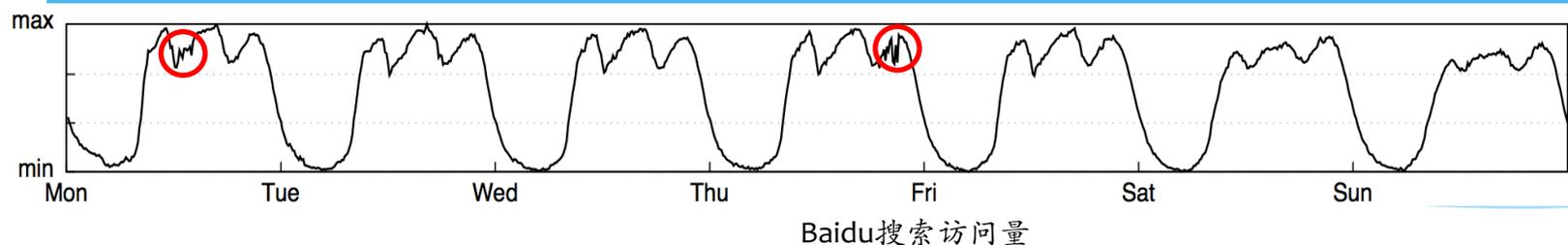
- 接受实验控制器对于运行某一个模块的请求。
- 管理模块的运行、存储结果并汇报实验控制器。



云平台

## Strategy 2: Design deployable solutions

# KPI异常检测



**KPIs (Key Performance Indicators) : 用来衡量服务性能的关键指标**

**KPI异常行为 → 潜在的风险、故障、bugs、攻击.....**

**KPI异常检测 : 在KPI时序曲线上识别异常行为**

→ 诊断和修复

→ 阻止进一步损失或潜在风险

# 构建KPI异常检测系统



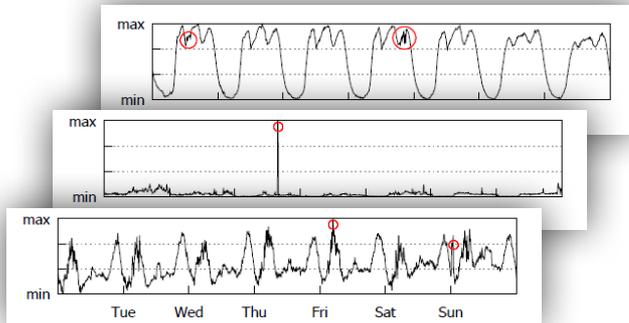
## 领域专家(运维人员)

- 对KPI负责
- 熟悉KPI的行为



## 算法开发人员

- 负责构建KPI异常检测系统
- 熟悉一些异常检测器 (算法)



Simple threshold

Historical Average

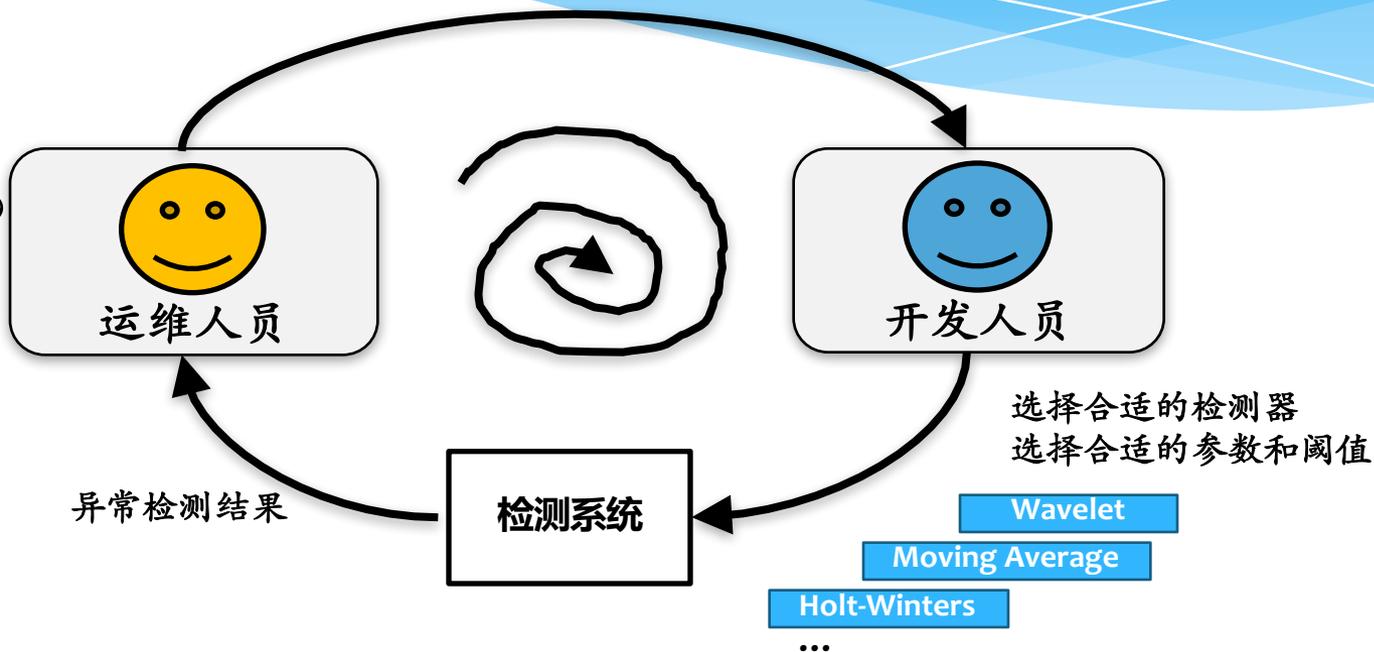
Wavelet

Holt-Winters

...

# 实践与挑战

描述异常



# 实践与挑战

描述异常

1. 运维人员难以事先给出准确、量化的异常定义

运维人员

开发人员

2. 选择和综合不同的检测器需要很多人力

3. 检测器算法复杂，参数调节不直观

异常检测结果

Moving Average

Holt-Winters

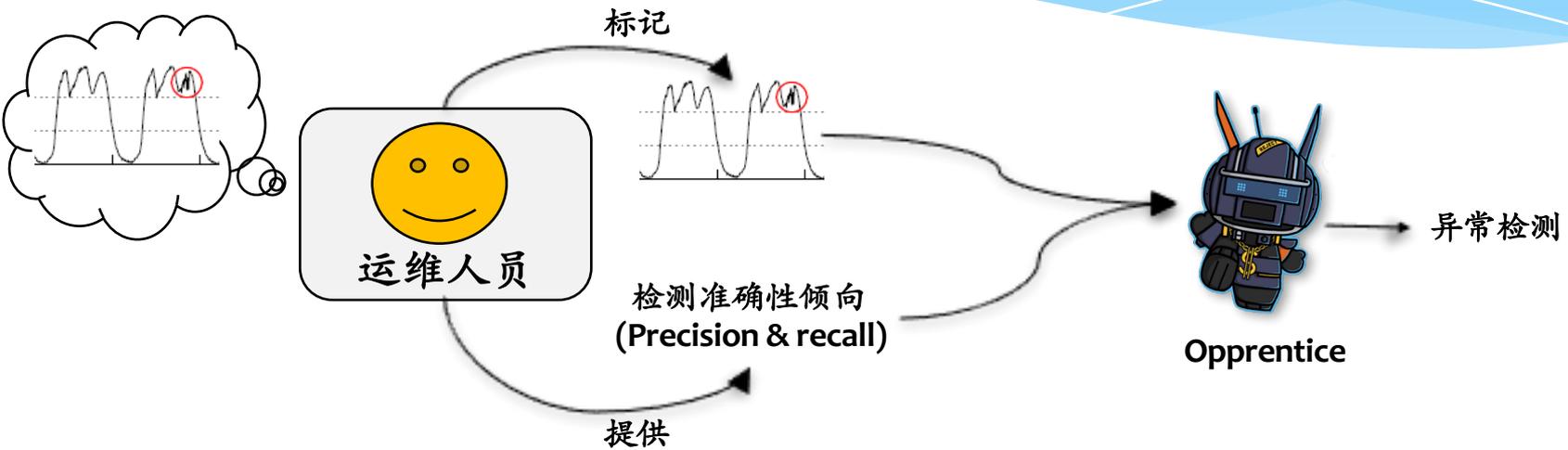
...

# 主要思想

Opprentice (Operator's Apprentice): 跟着运维人员从历史异常中学习



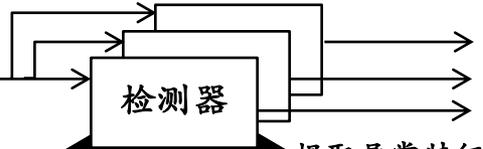
# 主要思想



# 主要思想



KPI 曲线



提取异常特征

Detector	Configuration
Simple threshold [23] / 1	none
Diff / 3	last-slot, last-day, last-week
Simple MA [4] / 5	win = 10, 20, 30, 40, 50 points
Weighted MA [10] / 5	
MA of diff / 5	$\alpha = 0.1, 0.3, 0.5, 0.7, 0.9$
EWMA [10] / 5	
TSD [1] / 5	win = 1, 2, 3, 4, 5 week(s)
TSD MAD / 5	
Historical average [5] / 5	
Historical MAD / 5	$\alpha, \beta, \gamma = 0.2, 0.4, 0.6, 0.8$
Holt-Winters [6] / $4^3 = 64$	
SVD [3] / $5 \times 3 = 15$	row = 10, 20, 30, 40, 50 points, column = 3, 5, 7
Wavelet [11] / $3 \times 3 = 9$	win = 3, 5, 7 days, freq = low, mid, high
ARIMA [9] / 1	Estimation from data
In total: 14 basic detectors / 133 configurations	

Historical average-4 season



EWMA-0,7



WMA-WIN30



Differencing-last slot



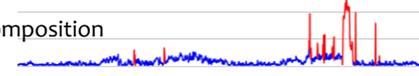
Differencing-last season



Differencing-last day



Time series decomposition



HW 0.2 0.2 0.2

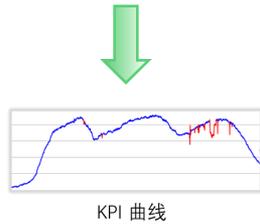
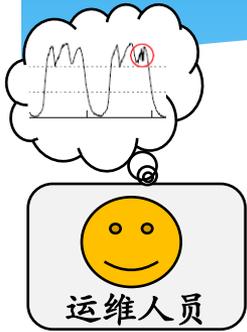


HW 0.5 0.7 0.7



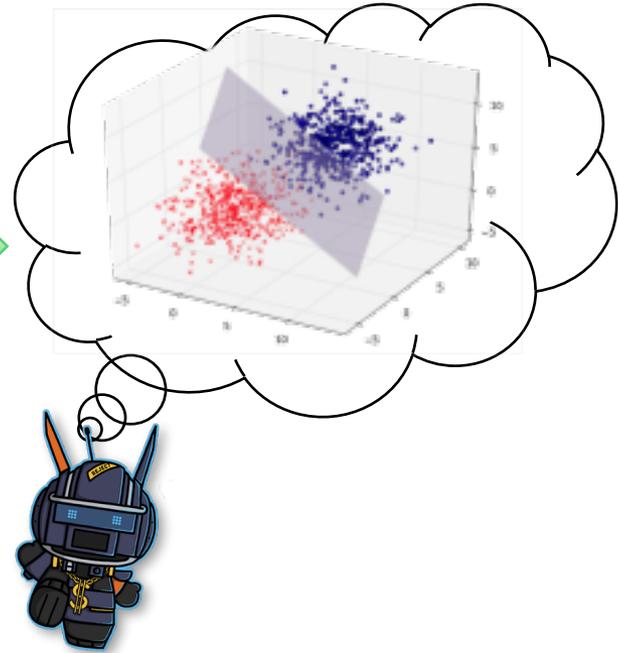
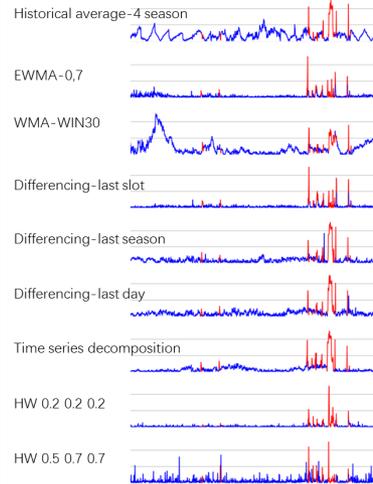
# 主要思想

## 异常特征空间分类 ——监督机器学习



检测器

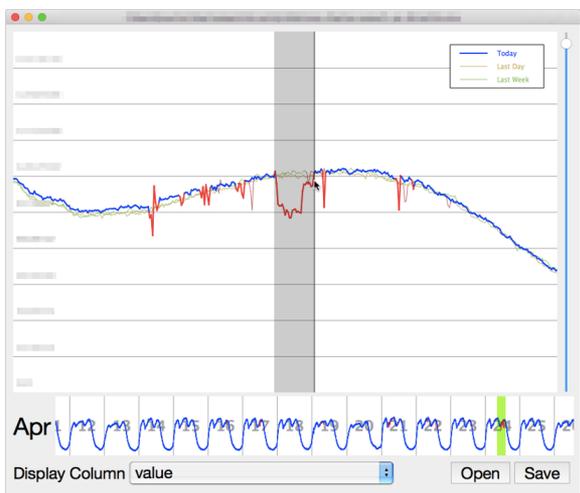
提取异常特征



# 挑战与解决方案

挑战1: 标记历史数据的开销

方案: 高效的标记工具



Y轴最大值调节

标记操作

拖拽  
标记异常窗口

拖拽  
取消标记

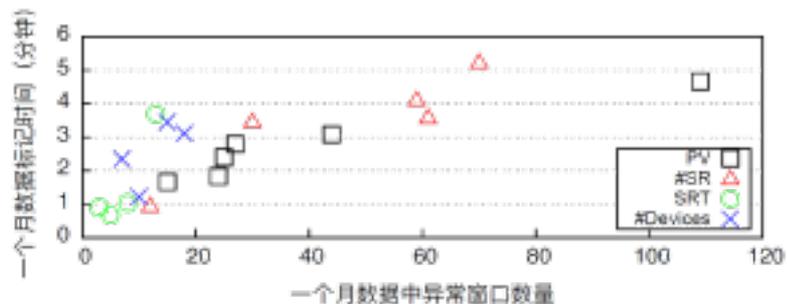
时序数据导航

缩小时间粒度

向后移动 向前移动

放大时间粒度

导航器



# 挑战与解决方案

挑战1: 标记历史数据的开销

→ 方案: 高效的标记工具

挑战2: 历史数据中异常种类少

→ 方案: 用最新的数据增量学习

挑战3: 类别不均衡问题

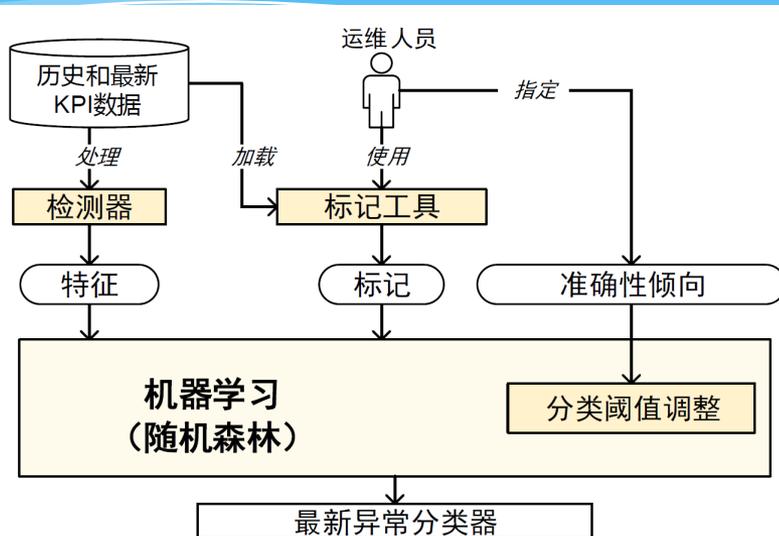
→ 方案: 根据检测准确性倾向调整分类阈值

挑战4: 冗余和无关特征

→ 方案: 随机森林

# Opprentice设计

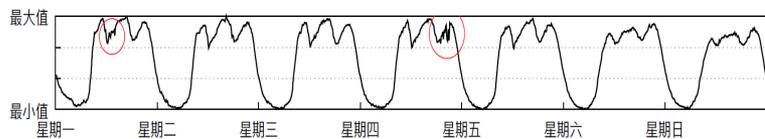
## 离线训练分类器



## 在线检测

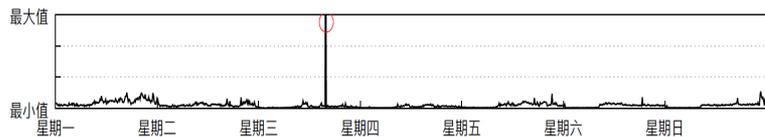


# 验证与评价



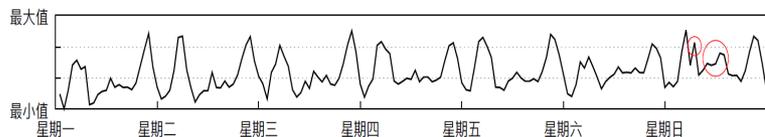
(a) KPI为搜索引擎访问量 (PV)。

搜索访问量 (25周)



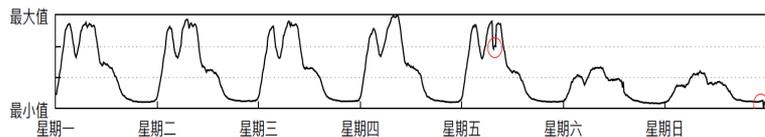
(b) KPI为搜索引擎数据中心慢响应数量 (#SR)。

数据中心慢响应数 (19周)



(c) KPI为搜索响应时间 (SRT)。

搜索响应时间 (16周)



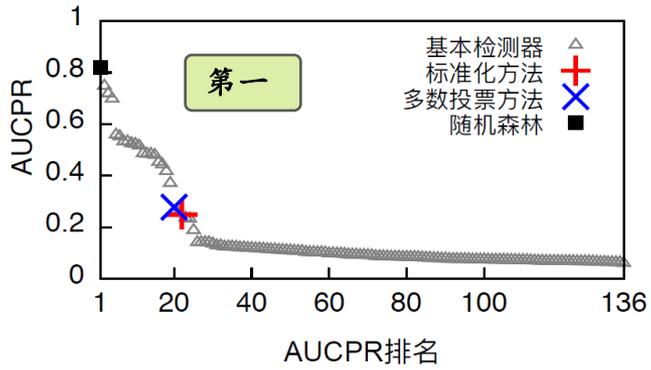
(d) KPI为校园Wi-Fi网络在线设备数 (#Devices)。

在线设备数 (15周)

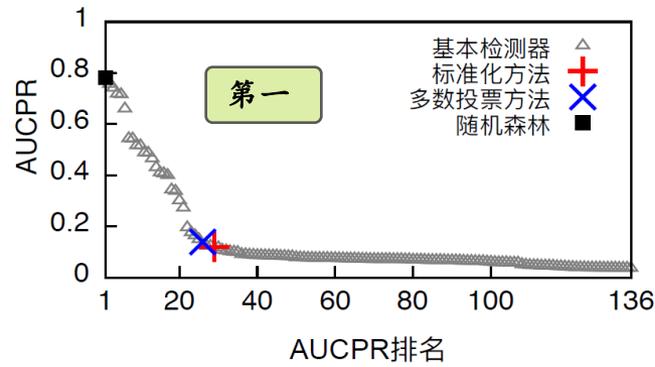
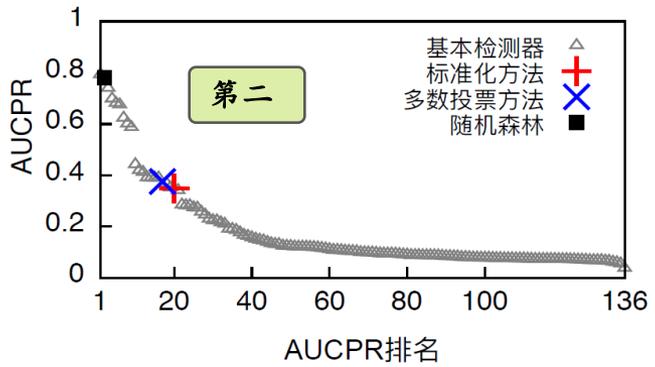
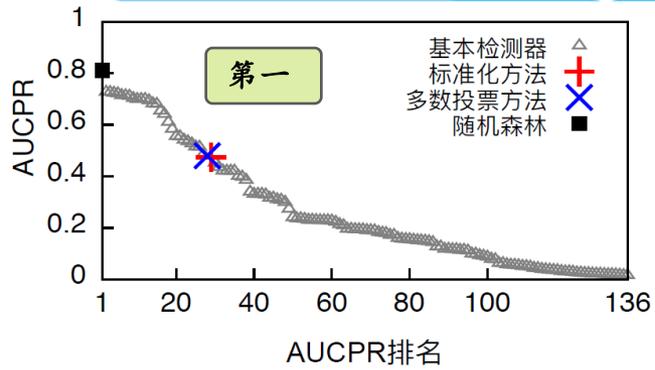
百度

清华校园  
无线网

# 验证与评价



去上



# Opprentice小结

- 通过学习历史异常数据自动构建异常检测系统
  - \* 无需人工选择繁杂的检测器和调参
  - \* 为复杂检测器的实际应用提供自动化框架
- 采用来自百度、清华校园网的数个月的真实数据验证

Strategy 3: When seeking solutions/algorithms,  
find inspirations from other fields

“a new simple but elegant solution, with  
straightforward insight and intuition behind it. ”

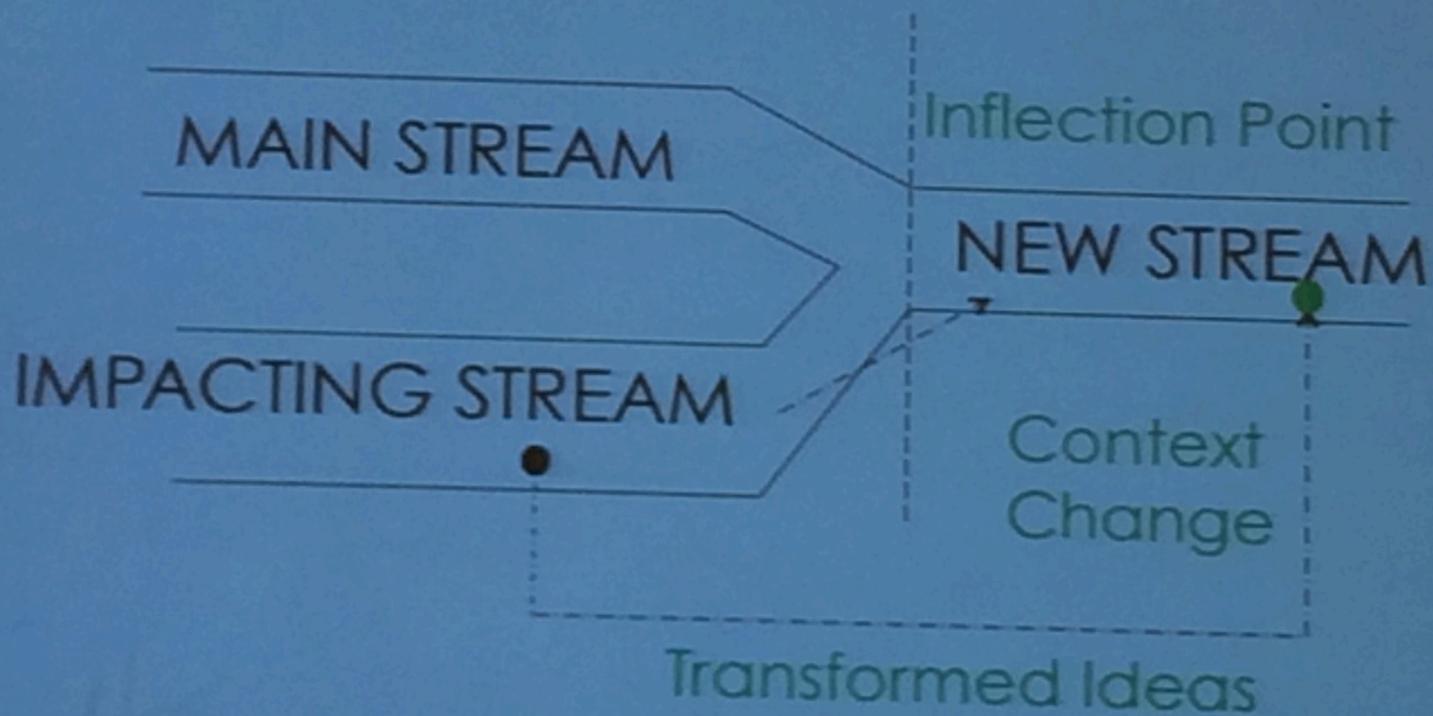
# Confluence: George Vargese

- \* George Varghese (Microsoft Research)
- \* SIGCOMM AWARD Winner 2014



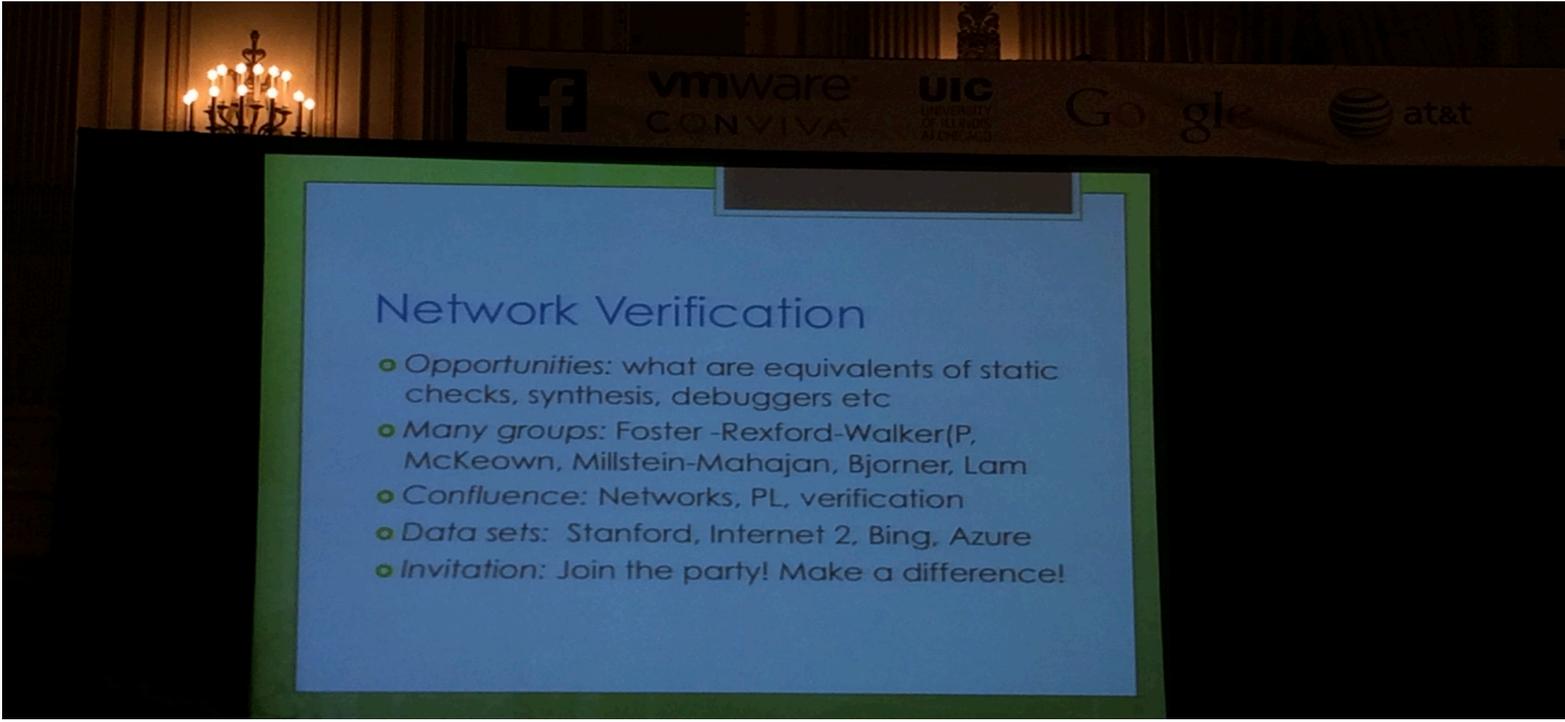


## Confluence Definition for this talk



# Pick your confluence

- Watch for Trends
  - Read Trade Rags
  - Listen to Grapevine
  - Talk to others (teenagers, kids)
- Know your Strengths
  - Collaborators
  - Personal skill set
  - Access to Data (secret weapons)



## Network Verification

- *Opportunities:* what are equivalents of static checks, synthesis, debuggers etc
- *Many groups:* Foster -Rexford-Walker(P, McKeown, Millstein-Mahajan, Bjorner, Lam
- *Confluence:* Networks, PL, verification
- *Data sets:* Stanford, Internet 2, Bing, Azure
- *Invitation:* Join the party! Make a difference!



\* 智能运维：

\* 我几年前的一个从“基于规则”到“基于学习”的一次经历

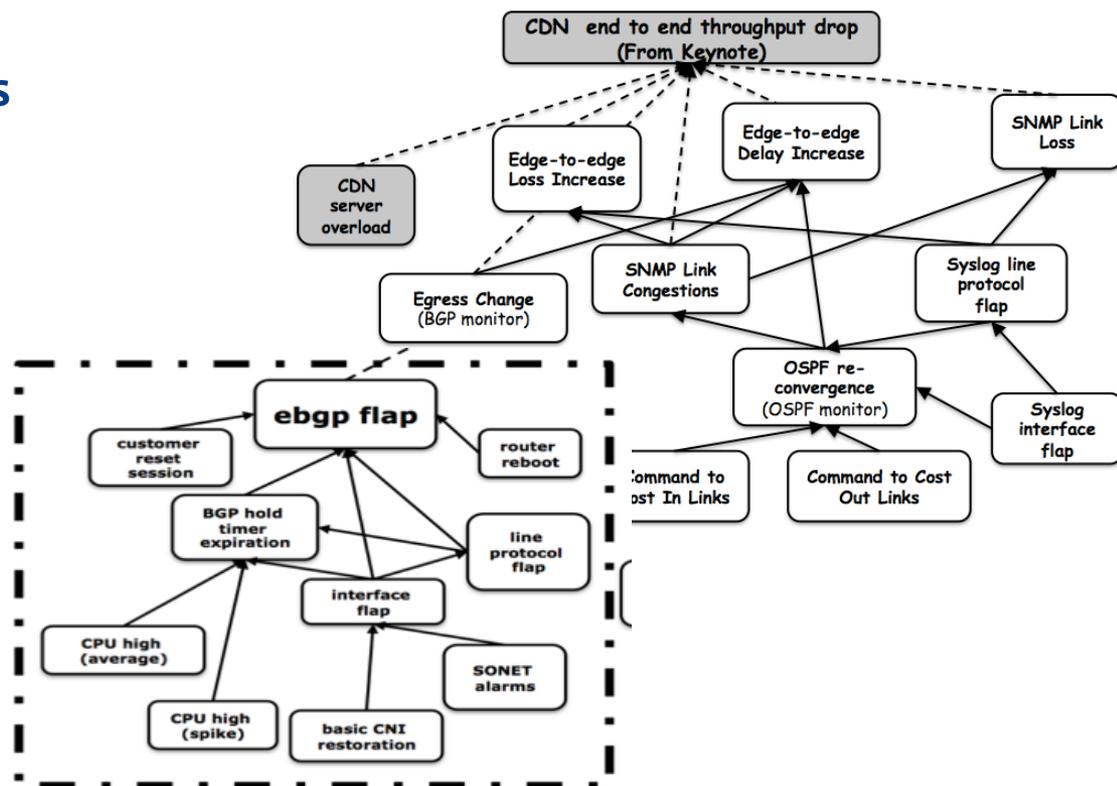
# 根因分析框架：G-RCA (Generic Root Cause Analysis)

## 基于规则

- 规则有运维人员人工给出
- 已在在AT&T产品化并常规使用
- 两篇学术论文
- 审稿人评价：“**revolutionizes troubleshooting Industry**”
- 两篇美国专利

## RCA Knowledge Library

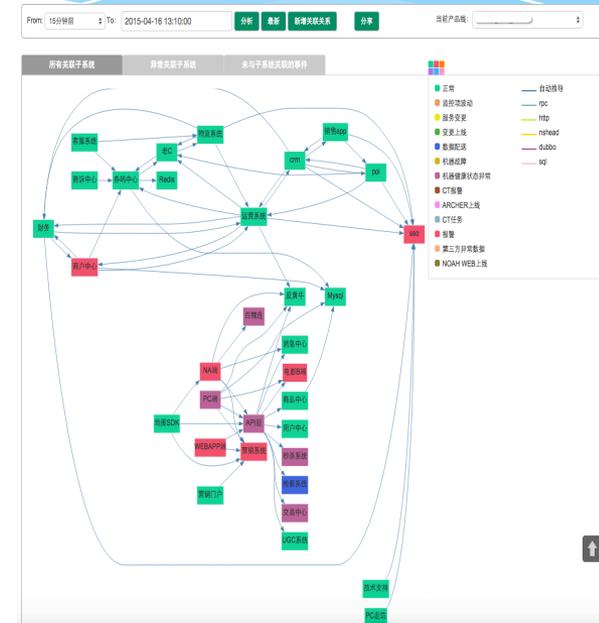
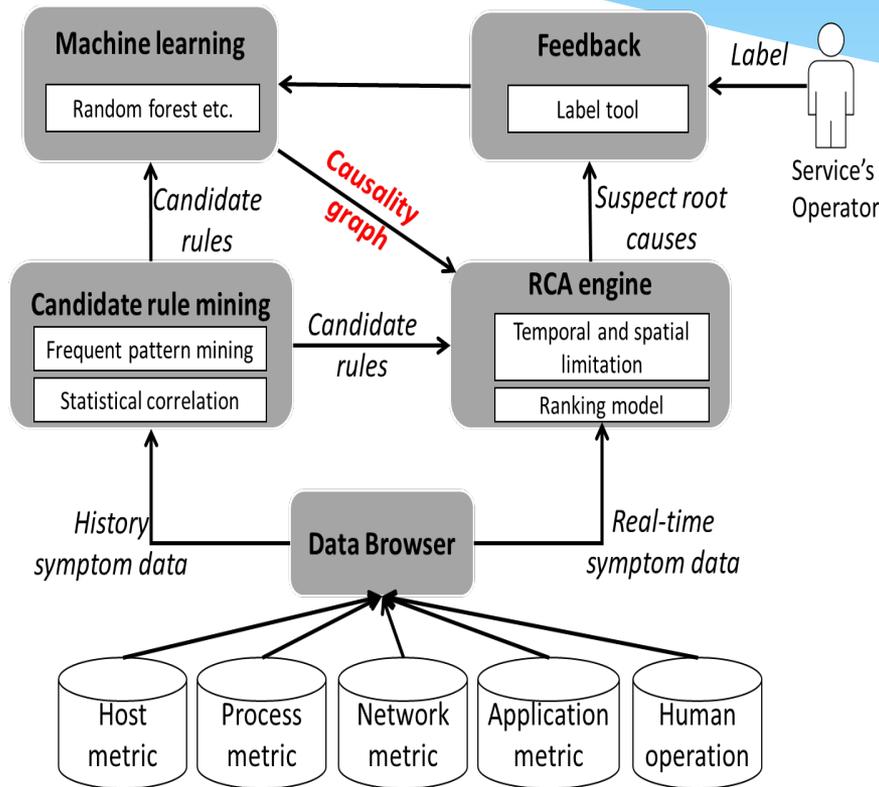
### • Application Diagnosis Graph



## 挑战：在互联网公司无法人工指定规则

- 规模大
  - 100多个产品线
  - 上万个模块
  - 几十万台服务器
  - 百万级KPI监控
- 变化快
  - 每天上万个软件更新
  - 互联网公司员工流动性强

# 机器学习来救场： 自动挖掘模块报警事件之间的关联关系



几轮学习之后几乎能100%把真实根因定位在top 3 备选根因里

# 机器学习成功案例的几大要素

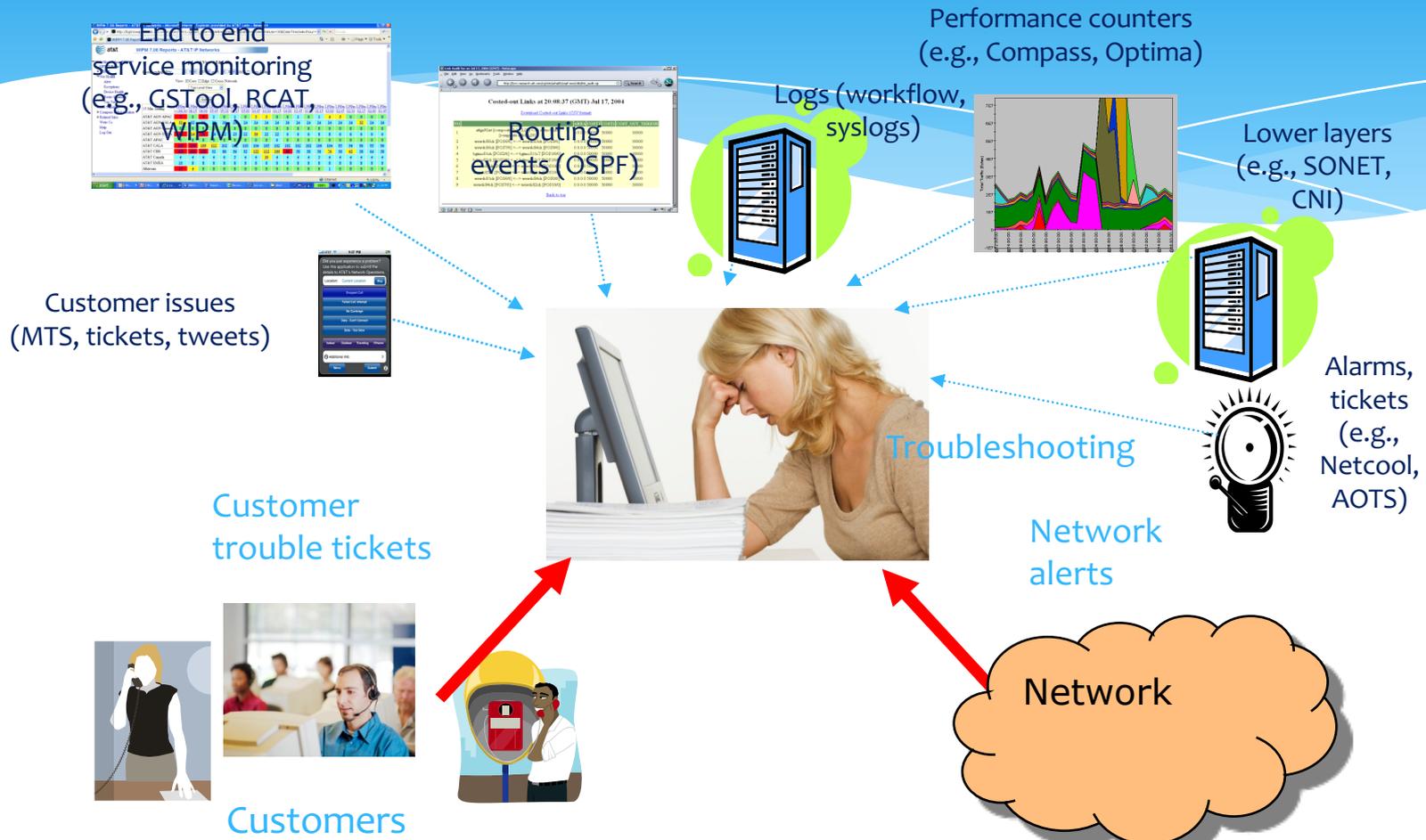
数据

标注

工具（算法和系统）

应用

# 互联网应用天然有海量日志作为特征数据； 还可以按需自主生成新的日志数据



# 运维日常工作产生标注数据

NSDI 2013

## What Does a Ticket Contain?

**STRUCTURED**

<b>Ticket Title</b>	Ticket #xxxxxx NetDevice: LoadBalancer Down 100% Summary: Indicates that the root cause is a failed system		
<b>Problem Type</b>	<b>Problem SubType</b>	<b>Priority</b>	<b>Created</b>
Severity - 2	2: Medium		

### STRUCTURED FIELDS

E.g., ticket title, problem type, priority etc.

**UNSTRUCTURED (Diary)**

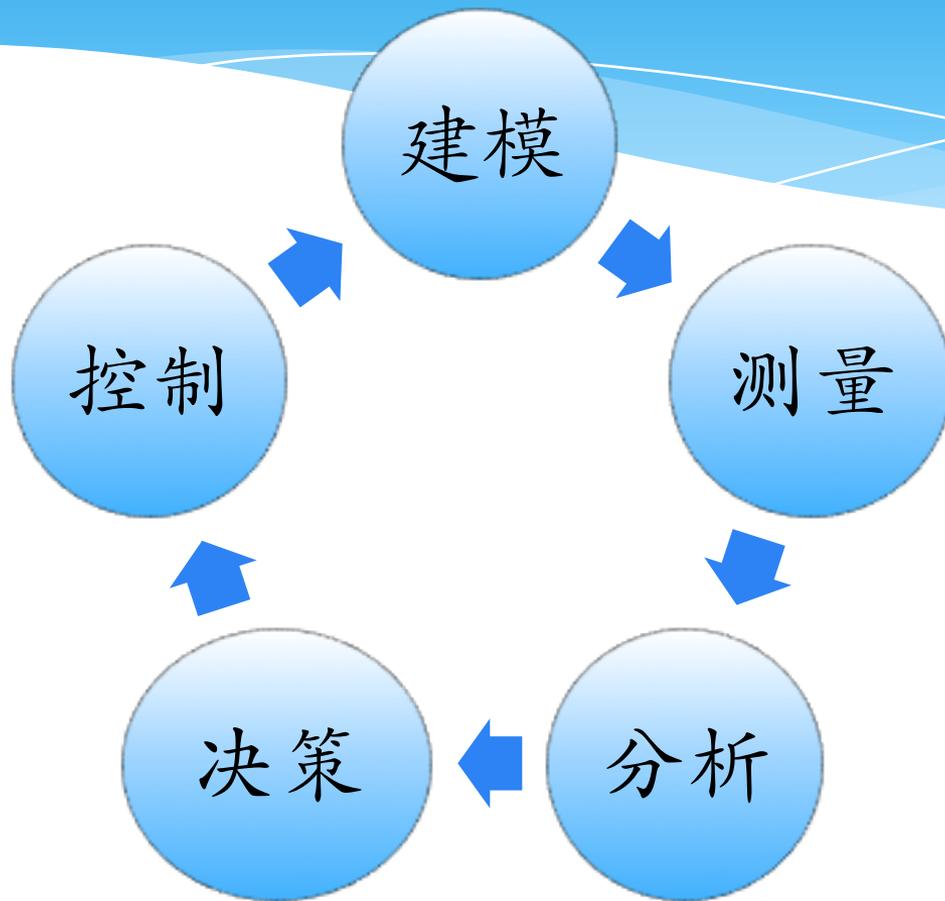
Operator 1: I replaced the memory chips on this device and both power supplies have been reseated  
Operator 2: The device has been powered back up. It should be back online shortly.  
Operator 1: Ok. Let me check.  
Operator 1: Yes. It is functional. Thanks!

--- Original Message ---  
From: Vendor Support  
Subject: Regarding Case Number #yyyyyy  
Title: Device xxx-xxx-xxx-130b v9.4.5 continously rebooting  
As discussed, the device has bad memory chips as such we replace it. Please completely fill the RMA form below and return it.  
--- Appended Message ---  
From: Operations  
Subject: Regarding Case Number #yyyyyy  
Title: Device xxx-xxx-xxx-130b v9.4.5 continously rebooting  
We have cleaned the cable connecting the load balancer to the access router. Please invoke device diagnostics and send the logs to the vendor for further troubleshooting.

### FREE-FORM TEXT

E.g., operator notes, emails, device debug logs, etc.

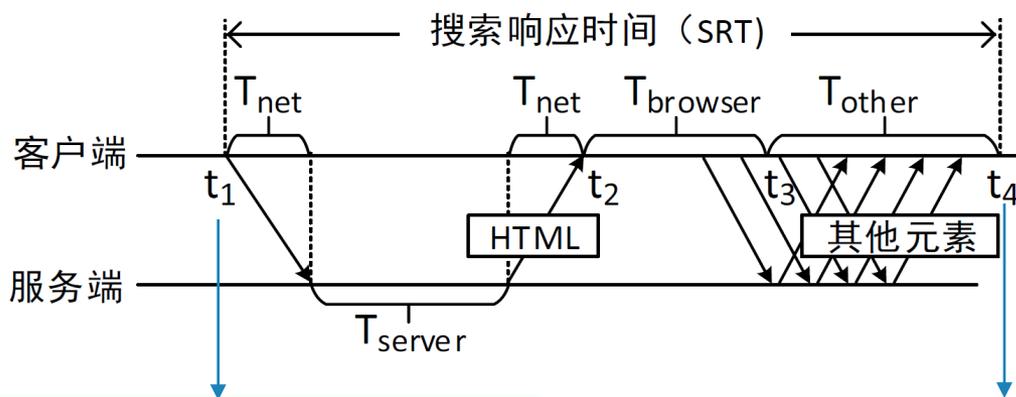
应用：运维人员就可以设计、部署、使用、  
并受益于智能运维系统，形成有效闭环



小结：智能运维在今后若干年会飞速发展

- “基于机器学习的智能运维” 具有得天独厚的基础
  - 互联网应用天然有海量日志作为特征数据
  - 运维日常工作日志产生标注数据
  - 大量成熟的机器学习算法和开源系统
  - 直接用于改善互联网应用

# 搜索响应时间SRT (search response time)



# Web响应时间的重要性



+500ms 利润↓ 1.2%  
[Eric Schurman, Bing]



+100ms~400ms 搜索↓ 0.2%~0.6%  
[Jake Brutlag, Google]

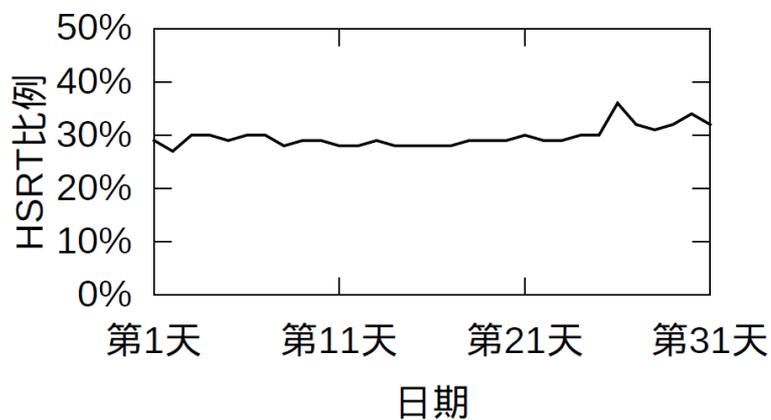
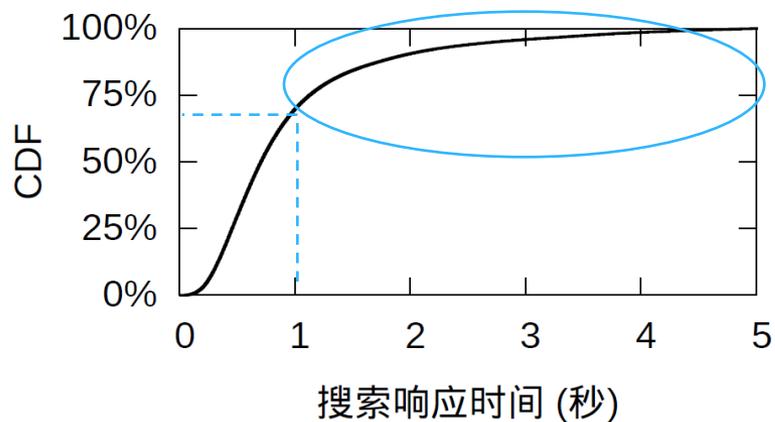


+100ms 销量↓ 1%  
[Greg Linden, Amazon]



+1000ms 访问量↓ 11%  
[Simic Bojan, Aberdeen]

# 实际中的搜索响应时间



问题：大于1秒的搜索 (HSRT) 是为什么?  
High SRT

# 搜索日志

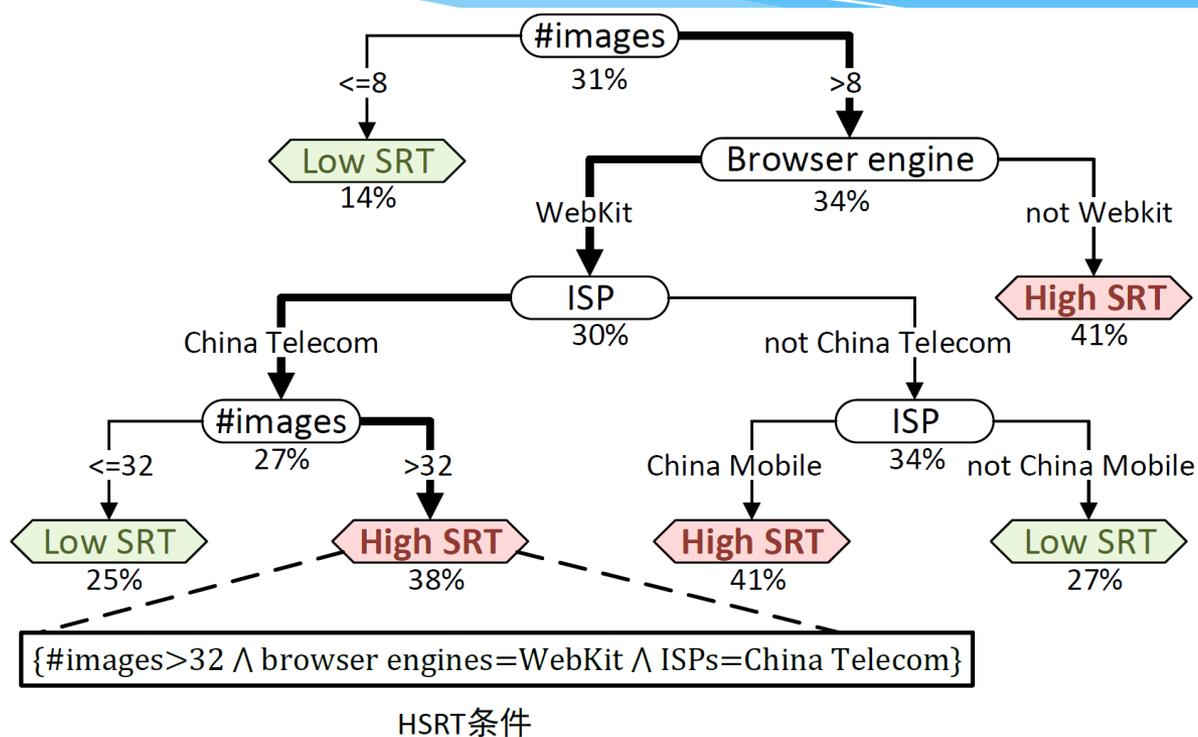
## 潜在可能影响SRT的可测量属性

SRT	Client ISP	浏览器内核	图片数量	有无广告	后台负载	.....
800ms (Low SRT)	China Unicom	WebKit	10	Yes	1000 PV/s	.....
1200ms (High SRT)	China Telecom	Trident 5.0	5	No	500 PV/s	
.....						

本项目提出搜索日志分析框架**FOCUS**来回答下面三个问题:

- HSRT容易发生的条件是什么?
- 哪些HSRT条件是相近的(HSRT条件类型),并且比较流行?
- 流行的HSRT条件类型中的各个属性和值对SRT有怎样的影响?

# 基于决策树的HSRT条件识别



# 实际优化部署

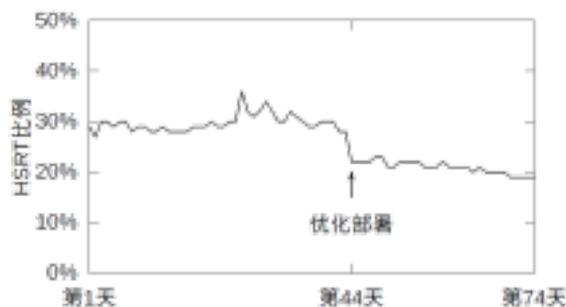
- FOCUS的分析结果显示优化图片有最大提升潜力
- 部署base64 encoding提高“数量多、体积小”的图片传输速度

HSRT比例

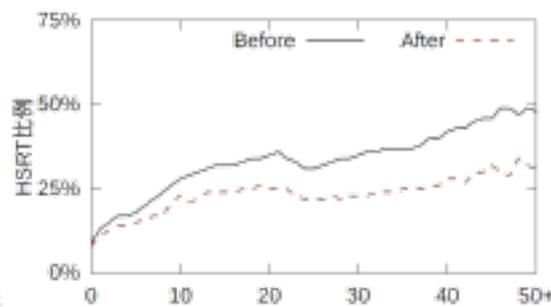
减少30%

SRT 80分位数

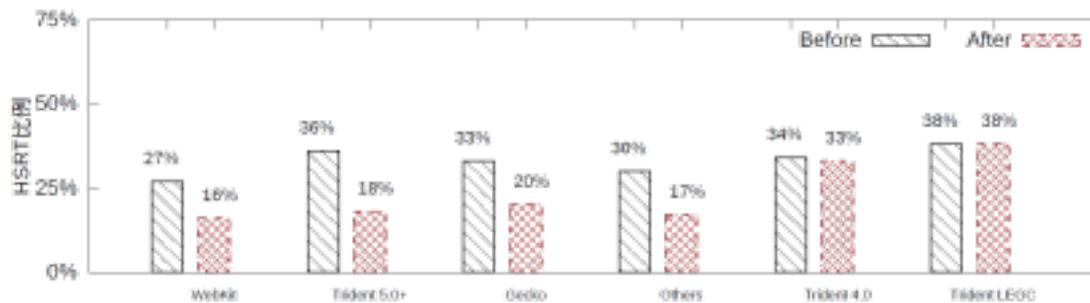
下降253 ms (20%)



(a) 每天HSRT比例。

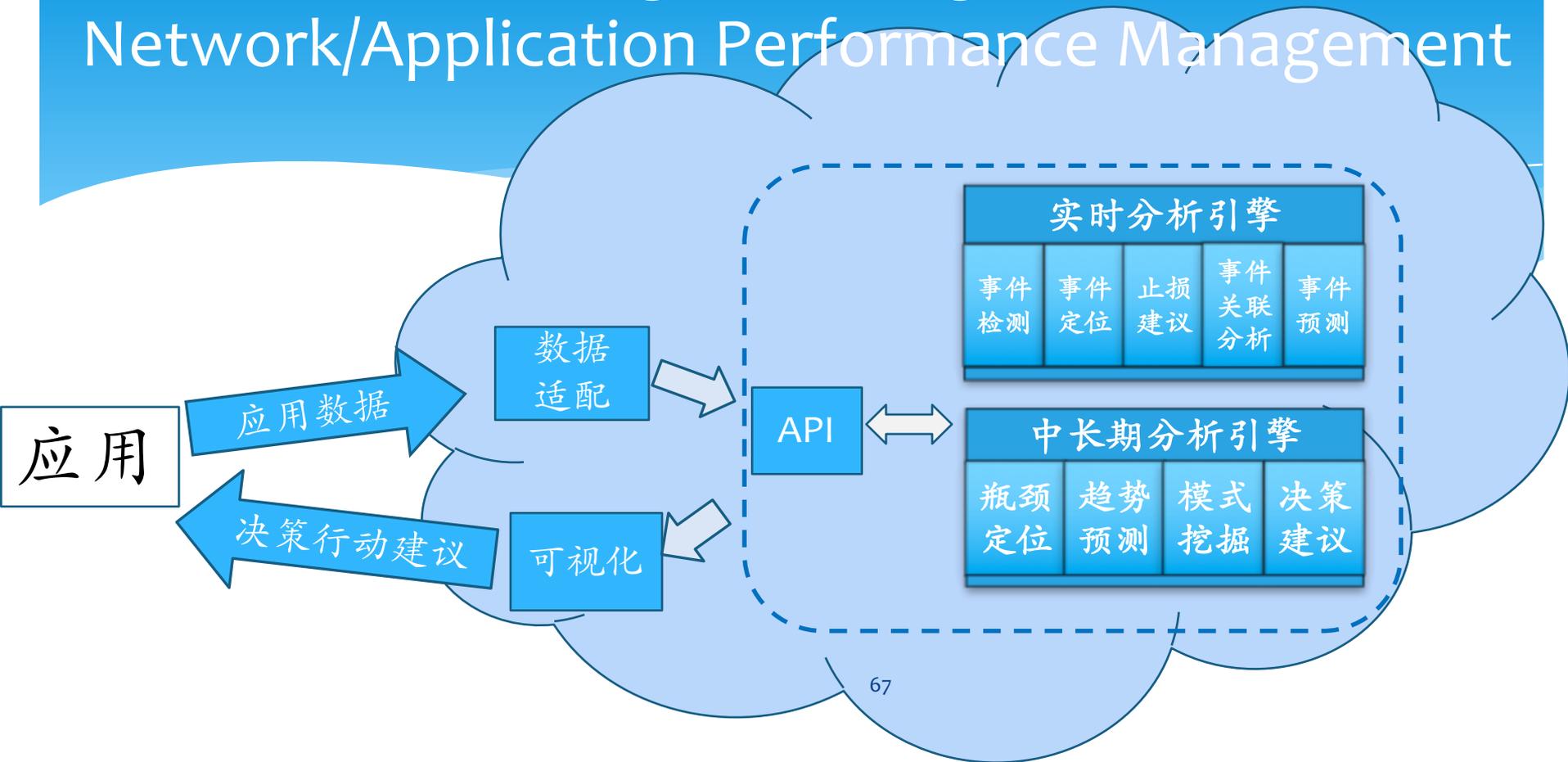


(b) 不同图片数量下的HSRT比例。



(c) 不同浏览器内核下的HSRT比例。

# Machine Learning Based Algorithm Suite for Network/Application Performance Management



时间戳	关键指标	属性1	属性2	...	属性n
-----	------	-----	-----	-----	-----

销售额、利润、订单数、PV、转化率、用户数、用户增速、留存率、首屏时间、闪退率、投诉率...



Cake: 一个大数据处理系统, 结合开源的计算平台, 使得机器学习实验易如反掌

# 概览

- \* 个人简介
- \* 导师、学生互相的期待
- \* 科研经验分享
- \* 论文写作经验分享

# On Improving Academic Writing in English

# English is our official language for written discussion

- \* PPT, Word/Latex Documents, Email, WeChat.
- \* It's hard at the beginning, but force yourself, and keep trying and you will see your improvement gradually.

# 关于论文撰写

- \* 不断积累notes，都是论文写作的点。自律坚持每天写点儿。
  - \* 早开始写。intro, background, data set, design, related work。
  - \* 持之以恒的写。
- \* 对于很多论文工作来说，搭系统是基础。不要割裂开。simulator 和 实际系统差异很大。
- \* 边作实验，边写论文实验部分，边作图。  
solid, thorough. 看看主要参考文献是怎么做的。
- \* 好Writing 的标准：不同领域的朋友、同学、家人能看懂。

# 目标会议，期刊

- \* 按照自己的目标毕业时间，用会议论文deadline切割一下毕业前的时间，计划一系列目标会议。
- \* 论文立项：Shoot high for the first work. 每个项目的第一次投稿目标至少是B类会。
- \* B类会要留下至少4个月的时间。A类6个月。

# 论文internal deadlines

- \* 1. 正式截稿日期前4周，是我们的internal deadline，要求完成complete draft：满足论文的格式和页数要求，不能超篇幅，能通过会议网站格式检查，英文流畅，逻辑清晰。并上传到会议网站。在此之前我不会动手修改。
- \* 2. 在internal deadline 之后，我从会议网站上下载的论文，根据conference reviewer 的标准给出审稿意见。3个工作日内我会给出是否继续投稿的建议。部分论文也会请一些其他老师给出审稿意见。
- \* 3. 我不建议投稿的，如果学生还要投，我在正式deadline 前至多动嘴不动手（优先级远低于我建议投的论文）。有可能都没机会在正式投稿前再认真读该论文。
- \* 4. 我建议投稿的，我会保证对论文通读。对A类B类，我会对abstract, intro, conclusion的质量负责，其它章节至少仔细修改一遍。对C类O类，abstract, intro, conclusion 会粗改一遍，其它章节我会给些修改意见，但是不会动手改。

# A few general rules

- \* Gold standard of academic writing: your roommate can understand your paper
- \* When you write, you think as if you are an audience of the paper
- \* Clarity is the most important
- \* Keep practicing

# Logic, Logic, and Logic (I)

- \* Logic 1: Paper Structure
  - \* Motivation, problem statement, intuition of the solutions, architecture, design, evaluation, related work, conclusion
  - \* Separate text into subsections, subsections, bullet points if you can
  - \* Transition texts between texts.

# Logic, Logic, and Logic (II)

- \* Logic 2: within a section
  - \* Every subsection can be summarized into a few words, and these words form a clear and logical flow
  - \* Every paragraph in a subsection can be summarized into one sentence, and these summary sentences can form a smooth and logical flow
  - \* If you cannot do the above, separate the texts into multiple sections or subsections.

# Logic, Logic, and Logic (III)

## \* Logic within a paragraph

- \* The roles of first sentence: transition from previous paragraph, and summarizing the main things for this paragraph. Don't put your summary sentence to the end of the paragraph
- \* Very smooth flow within the paragraph, sentence by sentence. Causal Relationships, or parallel relationships, summary-details relationship between the sentences should be crystal clear
- \* Do not interrupt the flow in a paragraph with unimportant sentences. Use footnote when you have to give some additional information.
- \* Do not use long paragraph. Separate long paragraph into short ones. If you have to, use bold fonts to visually divide the paragraph
- \* Do not use very long sentences. Avoid using "and" to put very different things into one sentence. If you have to use long sentence, use "," to separate so that the audience can clearly see the logic in the sentence (e.g. multiple parallel things)

# Recommended Reading (more on my course website

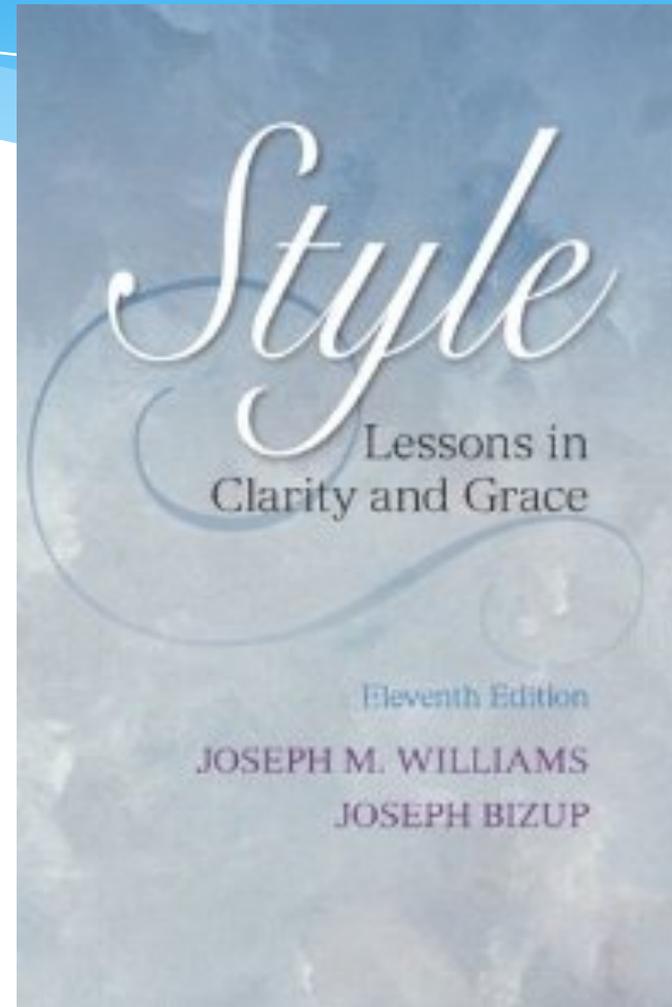
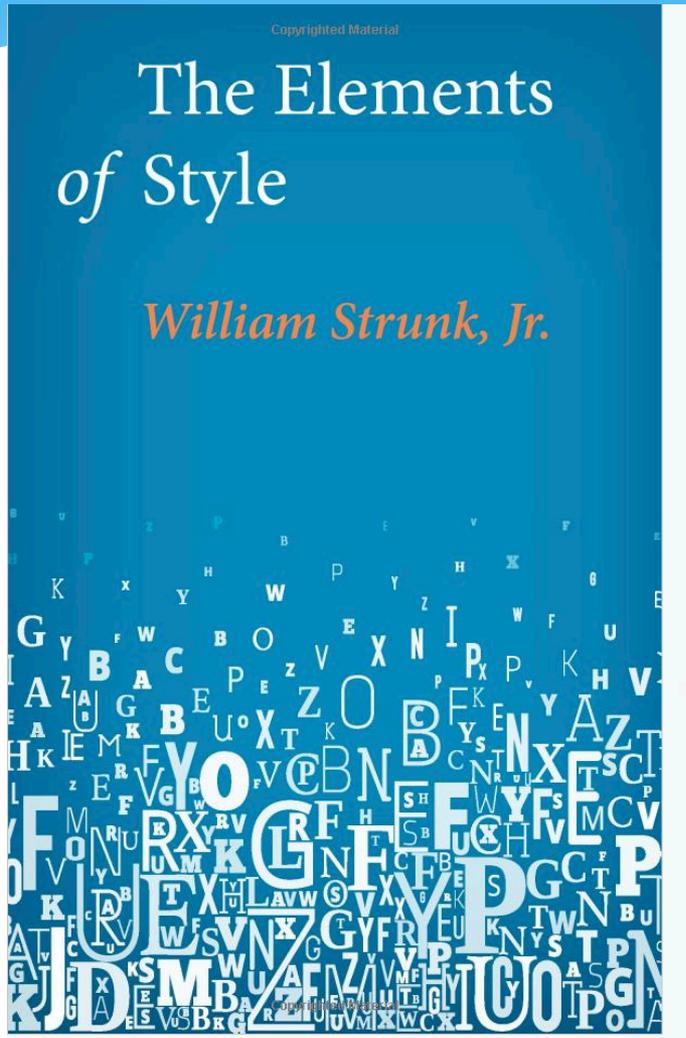
<http://netman.cs.tsinghua.edu.cn/~peidan/ANM> )

- \* [Using tenses in scientific writing](#)
- \* [Efficient Reading of Papers in Science and Technology](#)
- \* [The Elements of Style](#)
- \* [Style: Lessons in Clarity and Grace](#)
- \* [How to Write and Publish a Scientific Paper](#)
- \* [How to read a paper](#)
- \* [Common Bugs in Writing](#)

# How I improved my writing

- \* Learn from the major reference paper
- \* Learn from co-authors/editors
- \* Read writing tips from well-known researchers
- \* Take academic writing class
- \* Read a few books about writing

# Two Books that I read



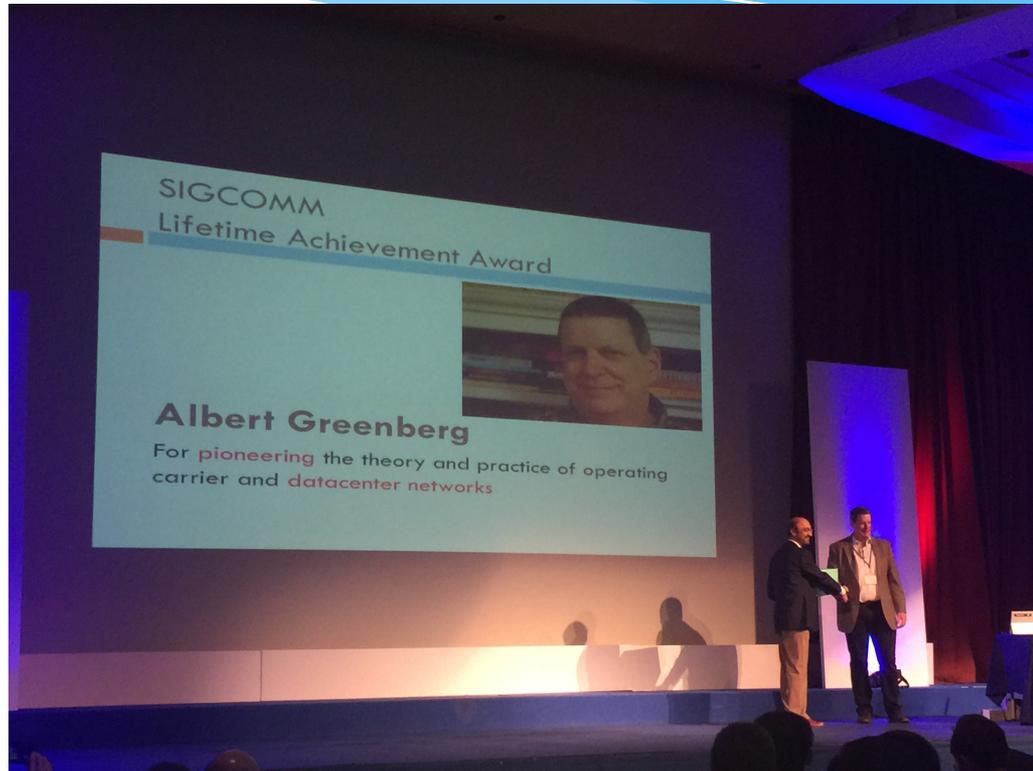
## TEN PRINCIPLES FOR WRITING CLEARLY

1. Distinguish real grammatical rules from folklore.
2. Use subjects to name the characters in your story.
3. Use verbs to name their important actions.
4. Open your sentences with familiar units of information.
5. Begin sentences constituting a passage with consistent topic/subjects.
6. Get to the main verb quickly:
  - Avoid long introductory phrases and clauses.
  - Avoid long abstract subjects.
  - Avoid interrupting the subject-verb connection.
7. Push new, complex units of information to the end of the sentence.
8. Be concise:
  - Cut meaningless and repeated words and obvious implications.
  - Put the meaning of phrases into one or two words.
  - Prefer affirmative sentences to negative ones.
9. Control sprawl.
  - Don't tack more than one subordinate clause onto another.
  - Extend a sentence with resumptive, summative, and free modifiers.
  - Extend a sentence with coordinate structures after verbs.
10. Above all, write to others as you would have others write to you.

# Summary

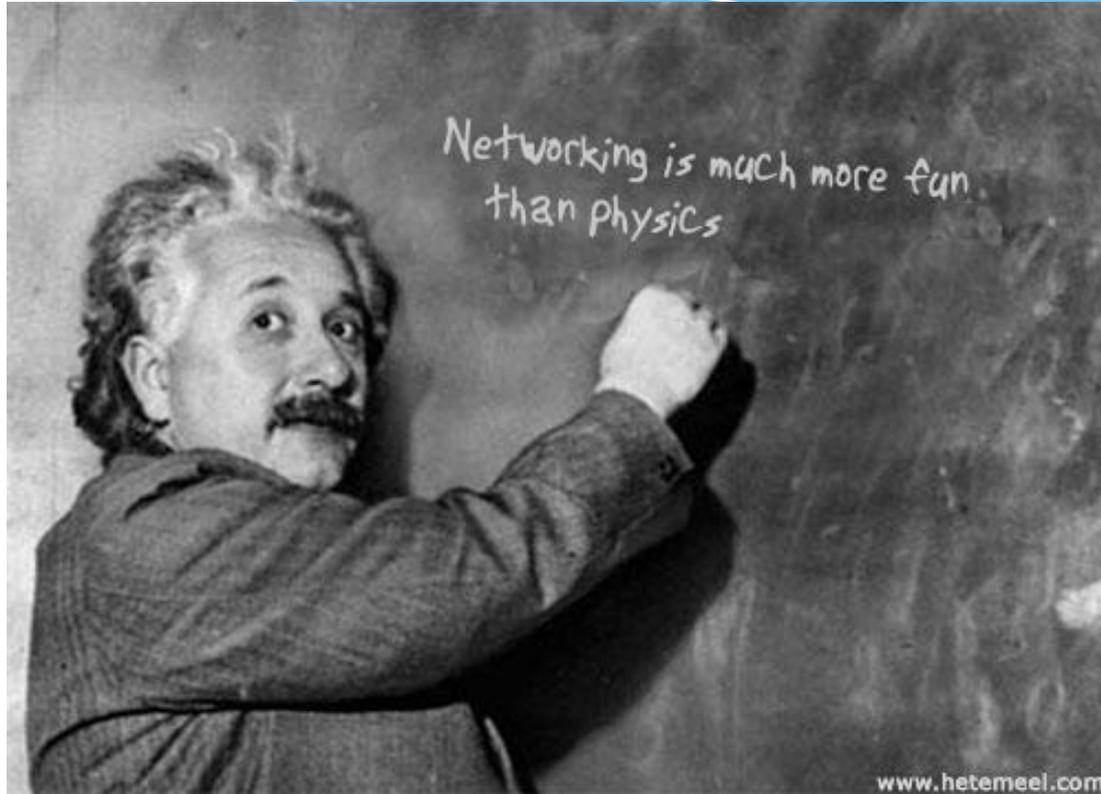
- \* Be proactive in your research
- \* Discover and define real world problem to work on
- \* Design deployable solutions, which are often very challenging by themselves.
- \* When seeking solutions/algorithms, find inspirations from other fields
- \* Plan ahead and submit well-polished papers to top-conferences.

# My motto: Innovate to impact



2015 SIGCOMM Award Winner Albert Greenberg's Quote: "How to win a test of time award? Spend five years to make it happen after publishing the paper."

祝大家做出一流的科研成果！



peidan@tsinghua.edu.cn