

# 混合CDN网络视频内容分发智能优化

## Proactive Video Push for Optimizing Bandwidth Consumption in Hybrid CDN-P2P VoD Systems

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# Outline

- **Video-on-Demand (VoD) systems in US and China**
- **P2P revives!**
- **Proactive video push in hybrid CDN-P2P system**
- **Conclusion**

# VoD systems in US and China

# 2016前后：自媒体、直播、付费视频、手游



新东方创始人，洪泰基金创始合伙人

头条认证：新东方创始人

动态 文章 视频 问答

1977-2017，你高考的时候有过什么难忘的故事？



今年是高考恢复40周年，1977年中国从文化大革命走出来，开始第一年的高考。那一年我...

387赞 · 102482人阅读

如何培养毅力？

一个人的成长过程，毅力和决心是非常重要的。不然，我们的梦想，目标就不容易实现。



# Pay for content, or ads-free content?

## ■ US

- Netflix/HULU: pay for watching TV shows & movies;
- YouTube: pay for the **ad-free content**;

NETFLIX



## ■ China

- IQIYI/Tencent Video/YOUKU :
- TV shows are usually **FREE** to watch;
- Pay for copyrighted, **ad-free content**.



# Ads in video playback

## ■ US

- YouTube: The Ads **can be skipped** after a few seconds;



Skip Ads

## ■ China

- **ONLY VIP** members can skip the Ads;
- The Ads last for minutes, may appear at the **beginning**, **during**, and at the **end** of the video playbacks.

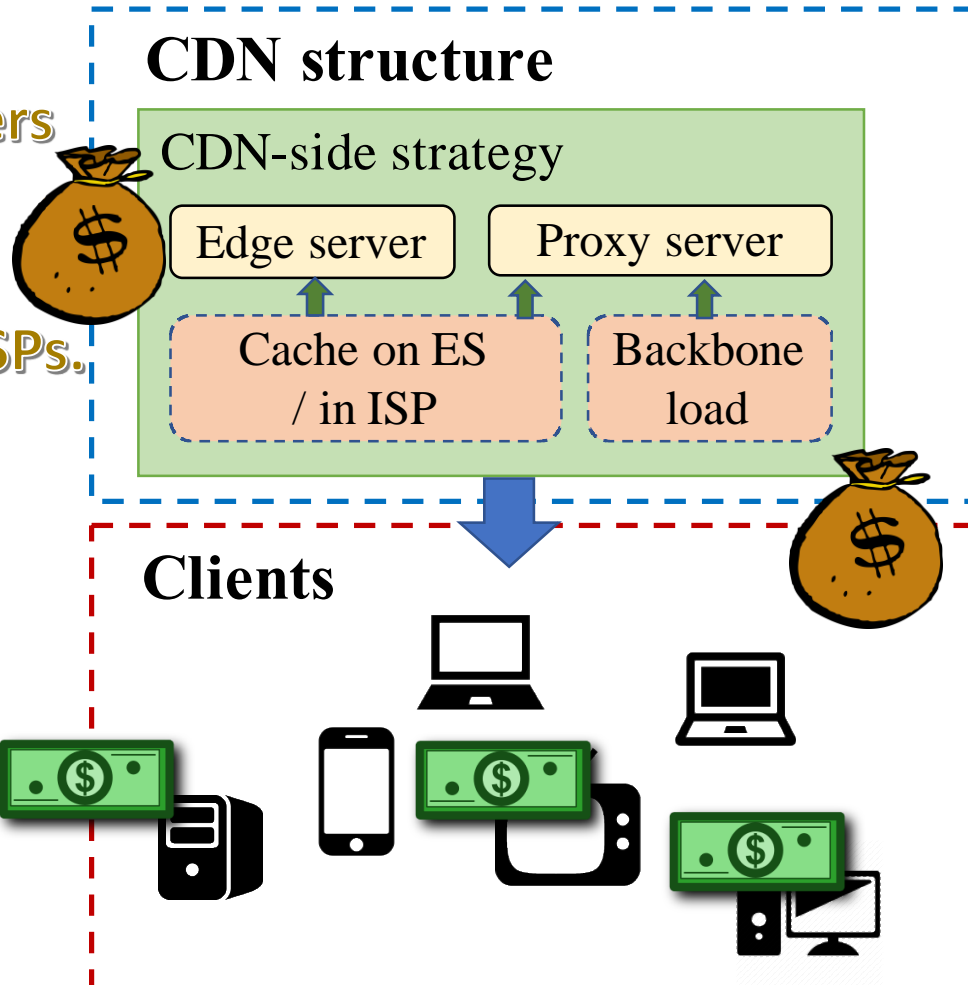


Wait or buy membership



# CDN cost charged by ISP

CDN servers  
spend on  
deploying  
cache in ISPs.



CDN output  
throughput / last  
mile delivery  
throughput is costly!

Users should pay  
for their access to  
the network.



# How would the ISPs charge?

- Charge by the **overall throughput**

- Large fluctuations in bandwidth consumption;
- Bandwidth utilization below 30% throughout a day;

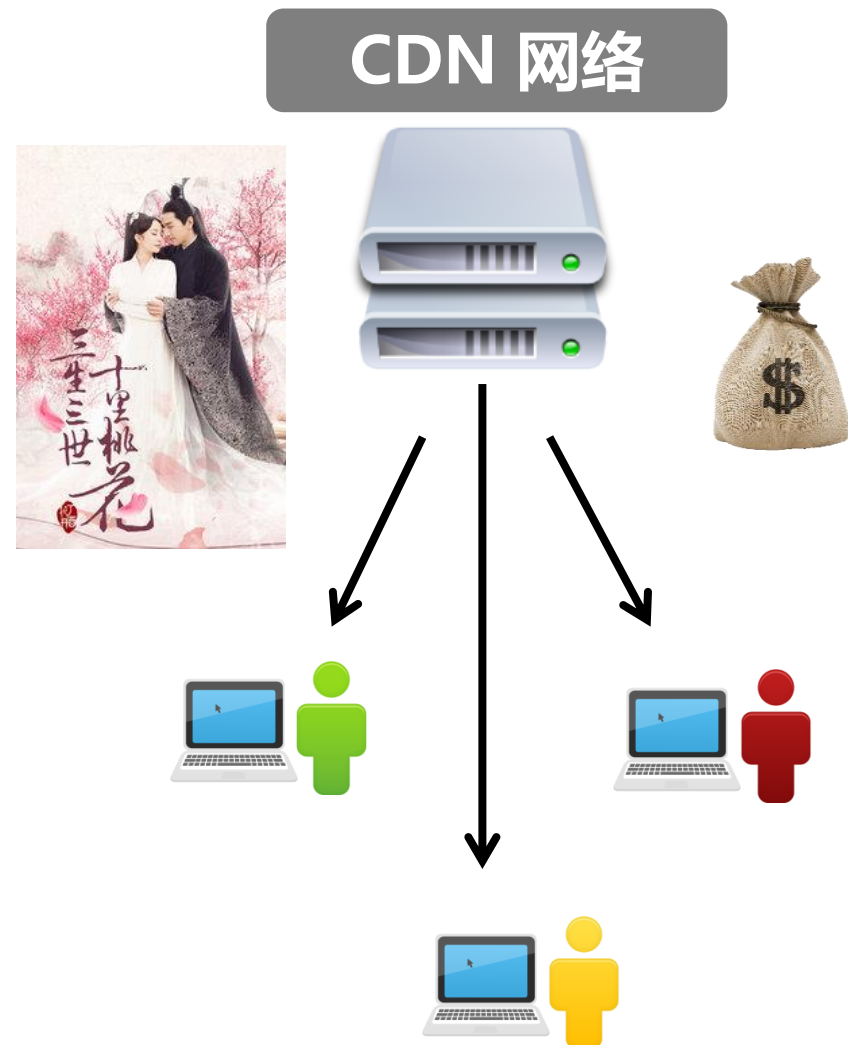
- In China, charge by the daily **peak bandwidth** consumption

- Stable bandwidth consumption;
- Bandwidth utilization above 30% throughout a day.



# 问题：视频CDN带宽花费太高

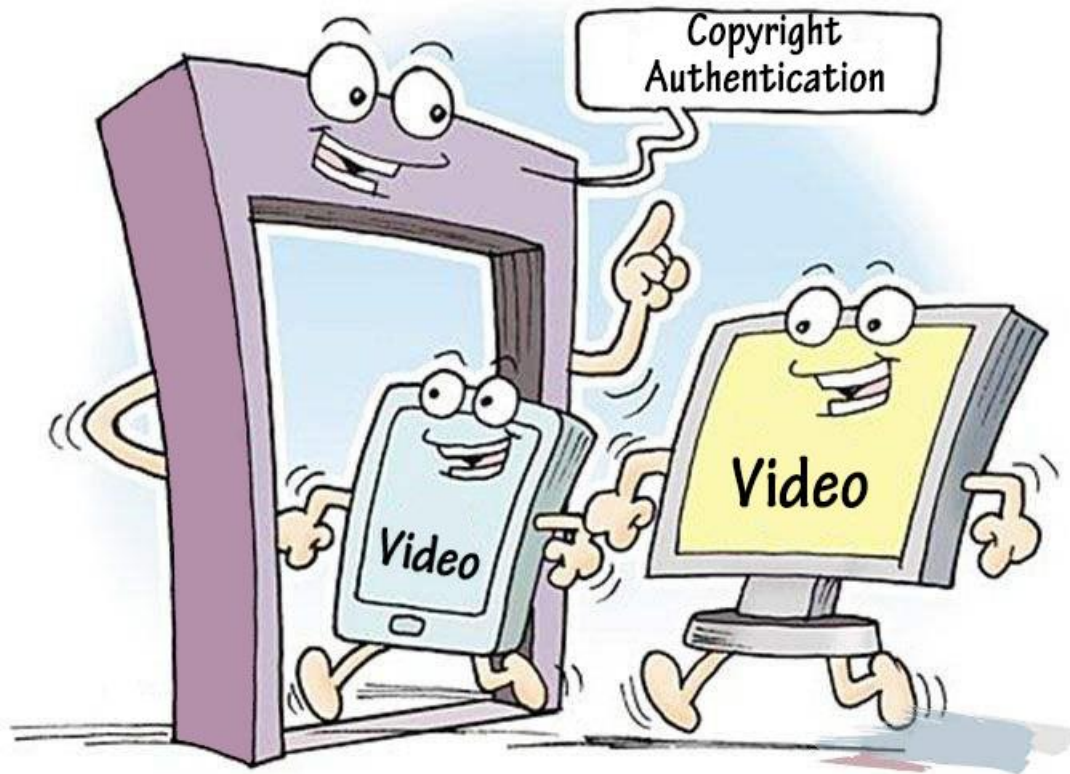
- 95计费、峰值流量计费
- 晚高峰8点以后
- 热门视频的下载突破峰值
- 带宽费用不断创新高



# P2P revives in the commercial VoD system

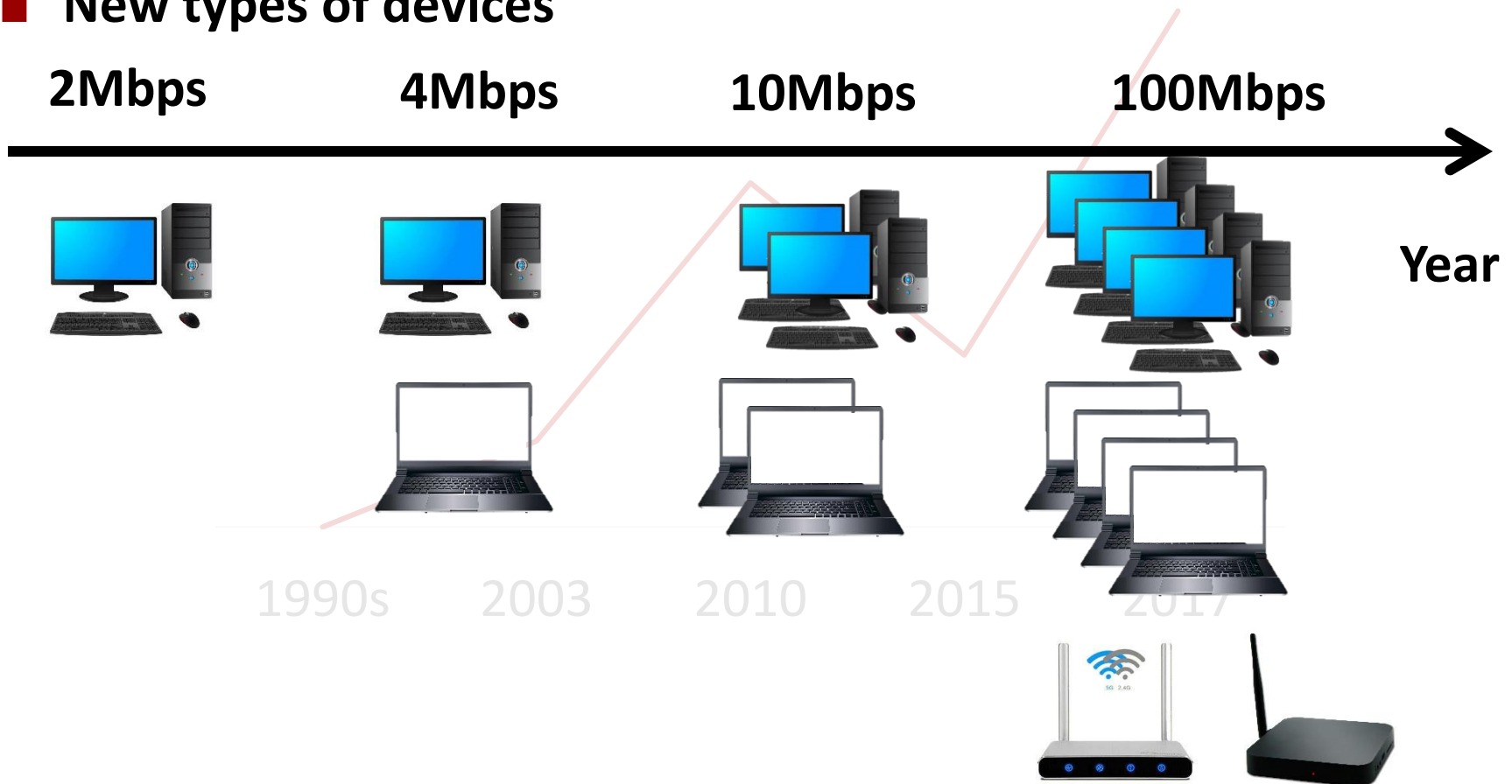
# Reviving P2P: copyright protection

## ■ The copyright authentication



# Reviving P2P: better network conditions

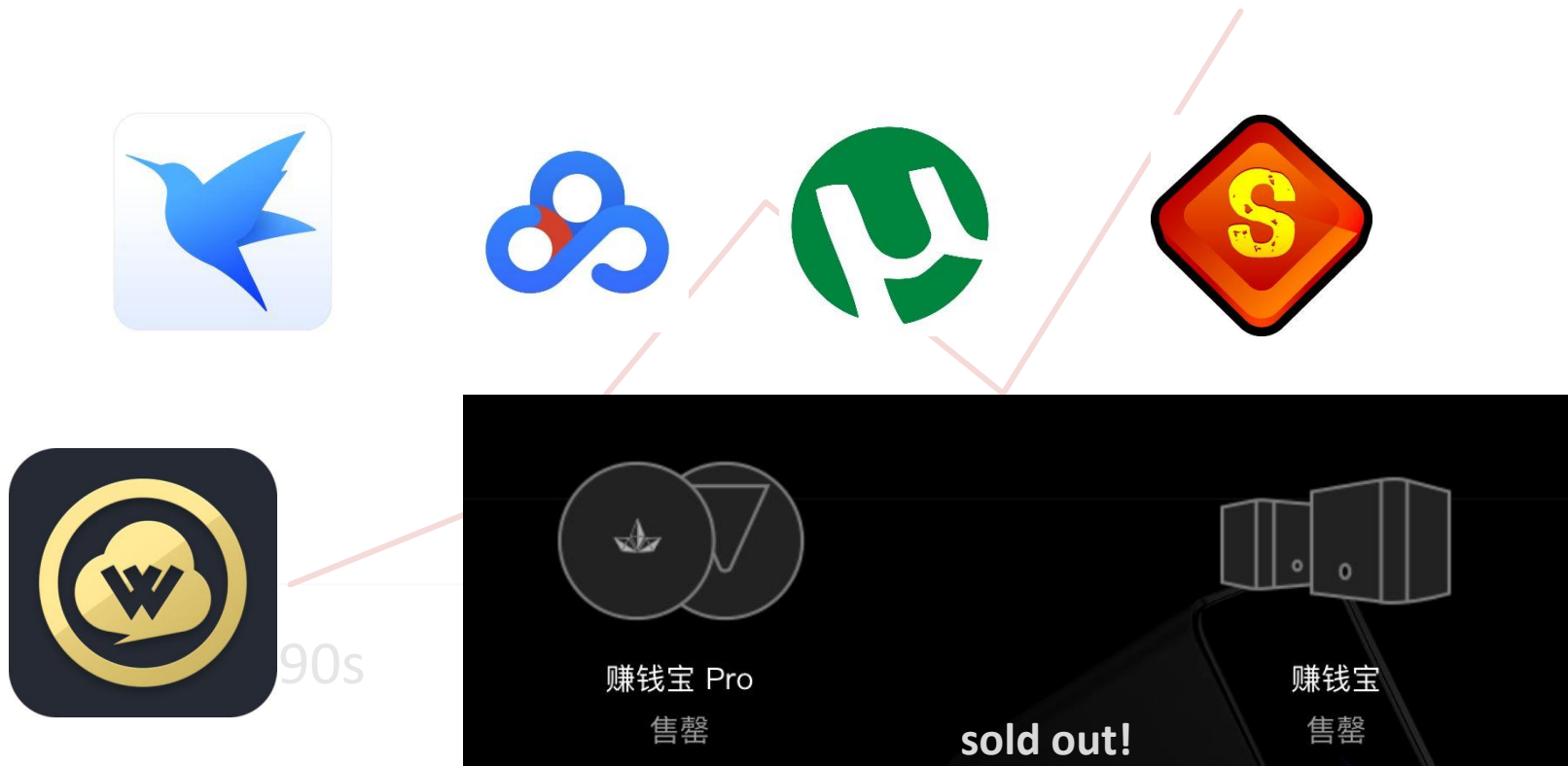
- Increasing bandwidth
- Dense network
- New types of devices



## Reviving P2P: ICO virtual coins

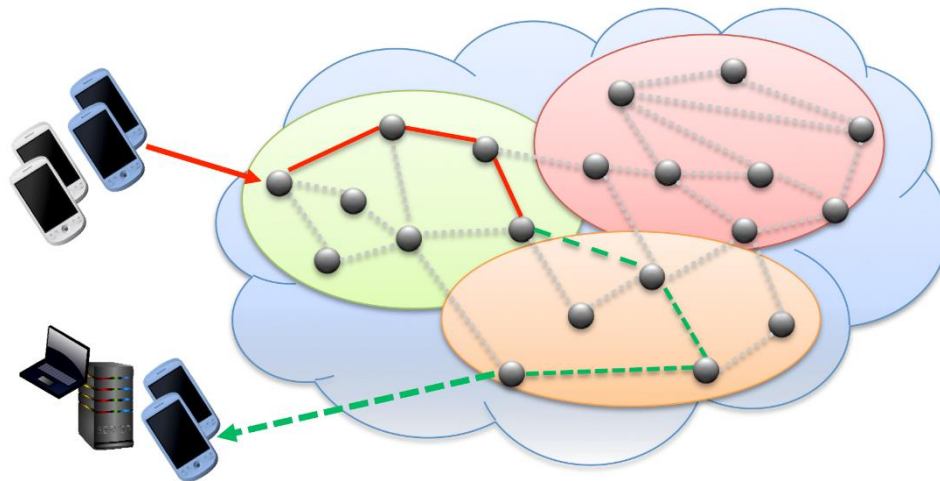
## ■ File sharing system + Blockchain

- Virtual coin reward



# Solution: Edge computing + P2P

- Push and store the contents with high popularity to edge devices;
- Decentralizing the transmission from server to edge devices



# Edge storage + P2P become reliable

## ■ The video data is encrypted.

- The Hijacked data can not be played.
- The videos can only be played by specific players.

## ■ The copyrights of the videos are strictly authenticated.

- All videos are copyright reserved.
- Watermarks and copyright laws to prevent pirate.

## ■ A large number of candidate peers (edge devices).

- More and more edge devices.
- New types of devices.



# Typical edge devices

## ■ 电脑: PCs such as laptops, desktops, Mac.

- Upload and download data through the P2P network (without harming quality of experience); Store replicas of videos (without breaking an upper bound)



## ■ 移动设备: Mobile devices such as cell phones, pads.

- No uploading through the P2P network considering power consumption, charged throughput, computing power, etc.



## ■ 机顶盒: Over-the-top devices.

- High bandwidth; Long online time.



## ■ 智能路由器: Smart routers.

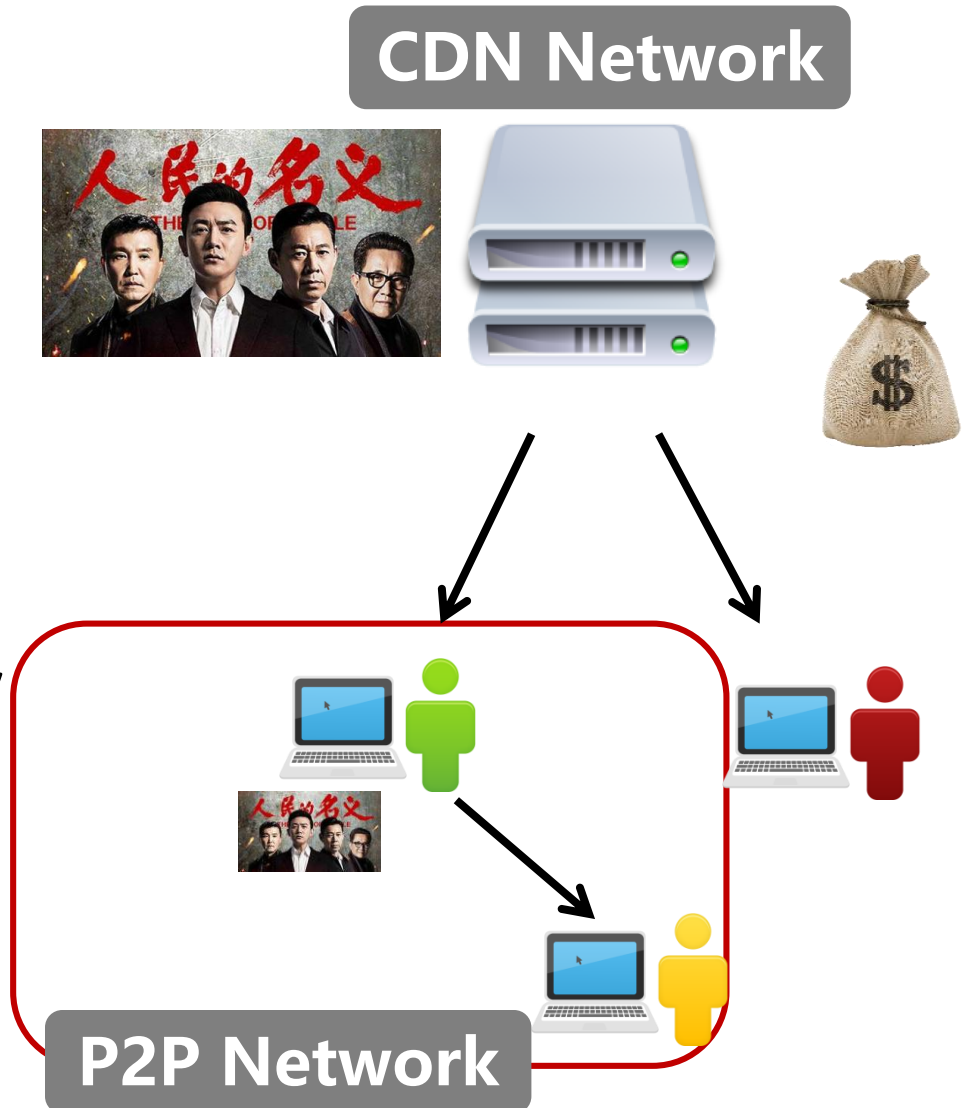
- Rewarded by virtual coins such as Wanke Coin.
- Always online.
- Can extend storage.
- Never request any playbacks.



## **Proactive video push** for hybrid CDN-P2P VoD systems

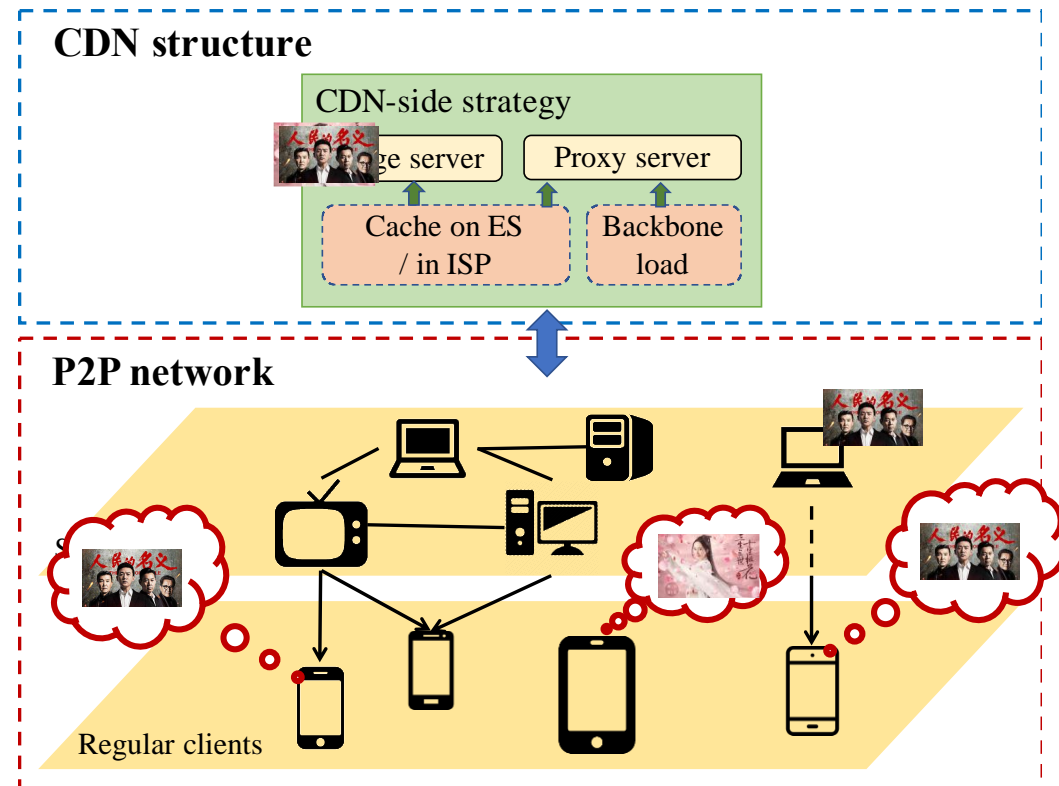
# Combine CDN and P2P techniques

- If the video is already in the P2P network:
- Clients could obtain data from other peers / edge devices;
- Instead of from CDN directly
- The expenditure is reduced.



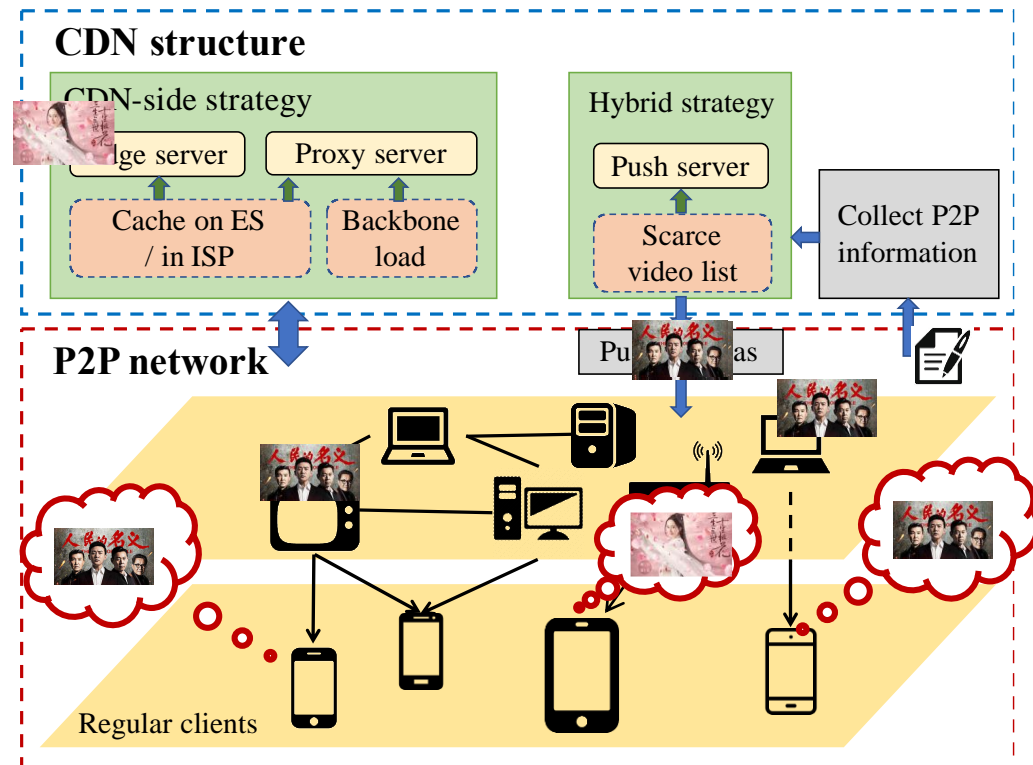
# Naïve CDN-P2P structure

- The client becomes a peer of the video after the playback;
- The accumulation of replicas is very slow.

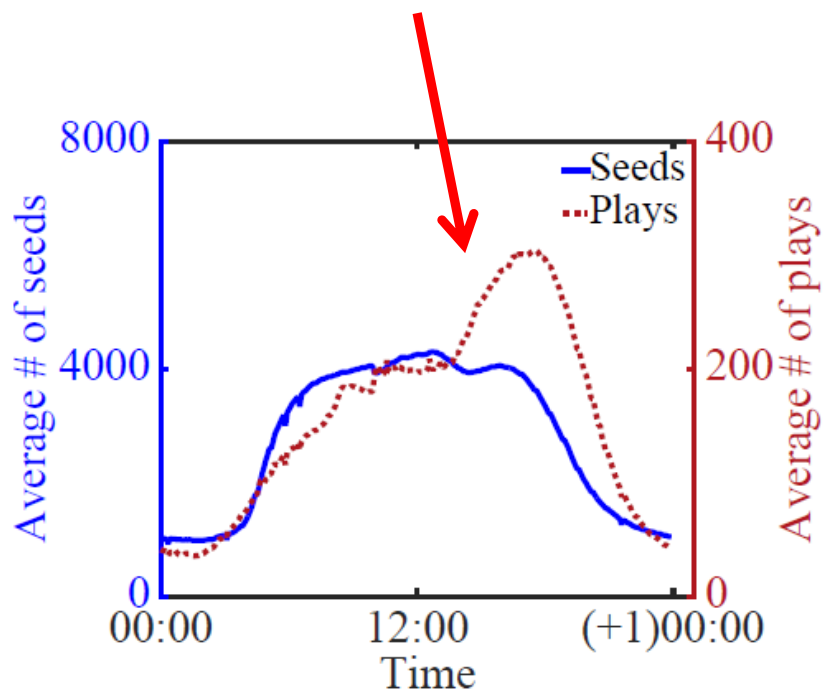


# Heuristic CDN-P2P structure: reactive push

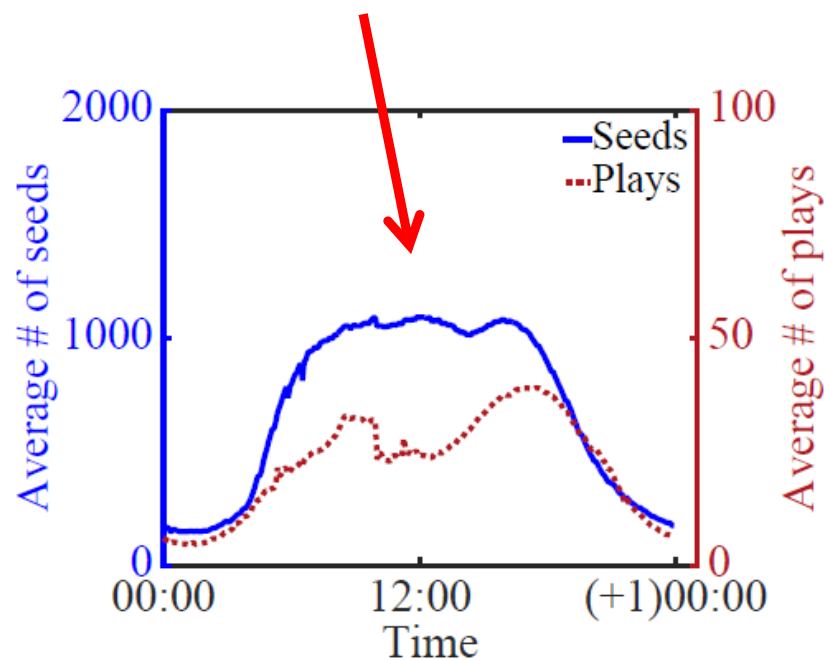
- First, the server pushes popular replicas upon requests of clients;
- Second, the client stores the replica in its buffer, and become a peer of the video.



# 晚高峰热门视频资源 (种子) 稀缺



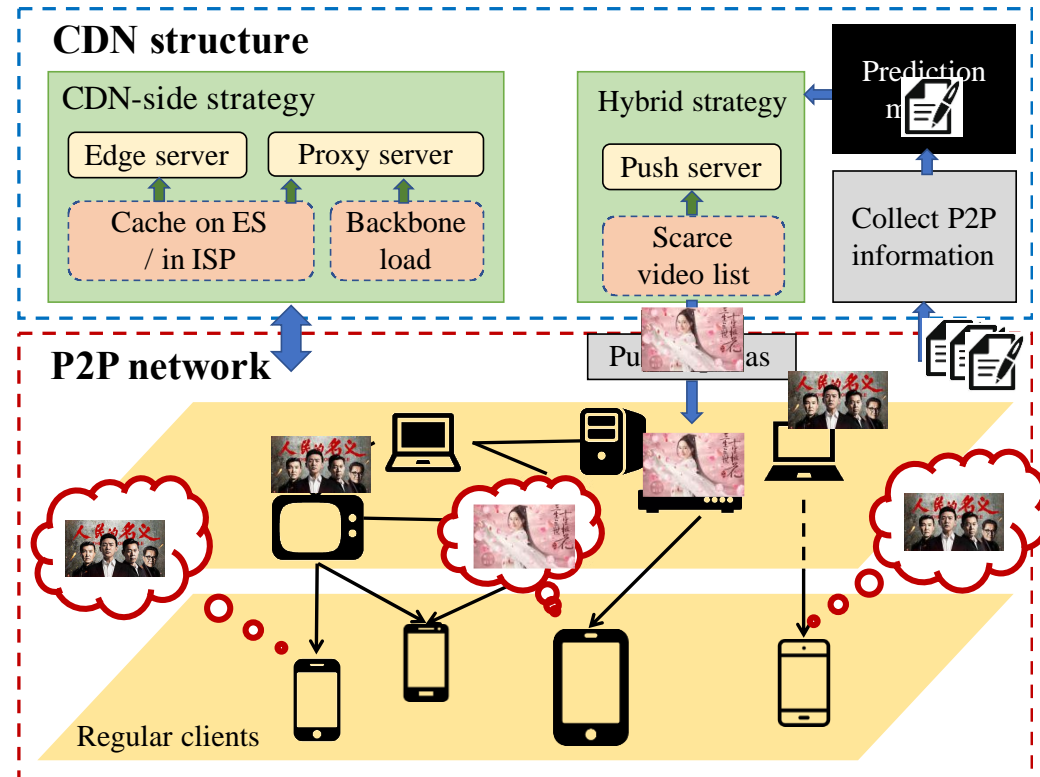
(a) Hot videos.



(b) Regular videos.

# Hybrid CDN-P2P structure: proactive push

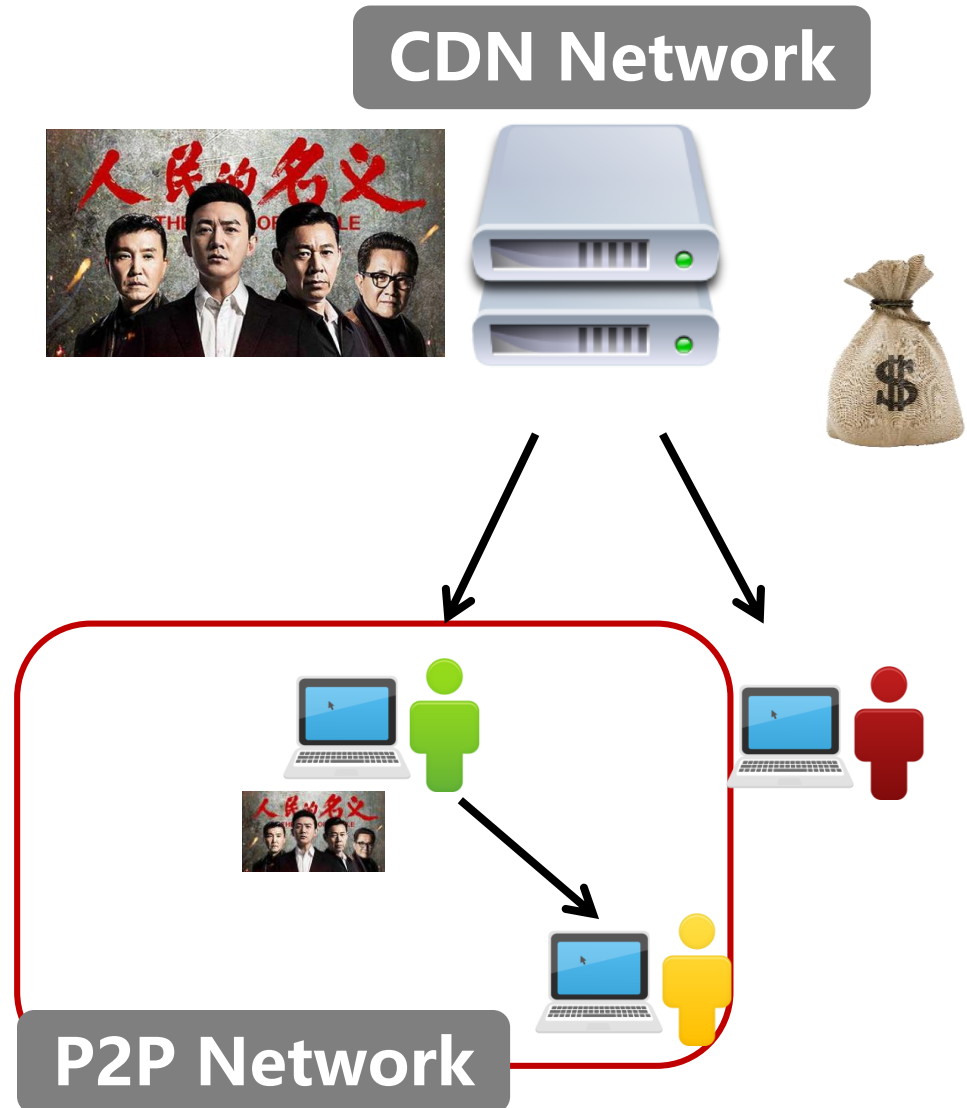
- Push popular replicas to edge devices **in advance**.
- Smart routers involved.
- Avoid cold-start of new released videos.



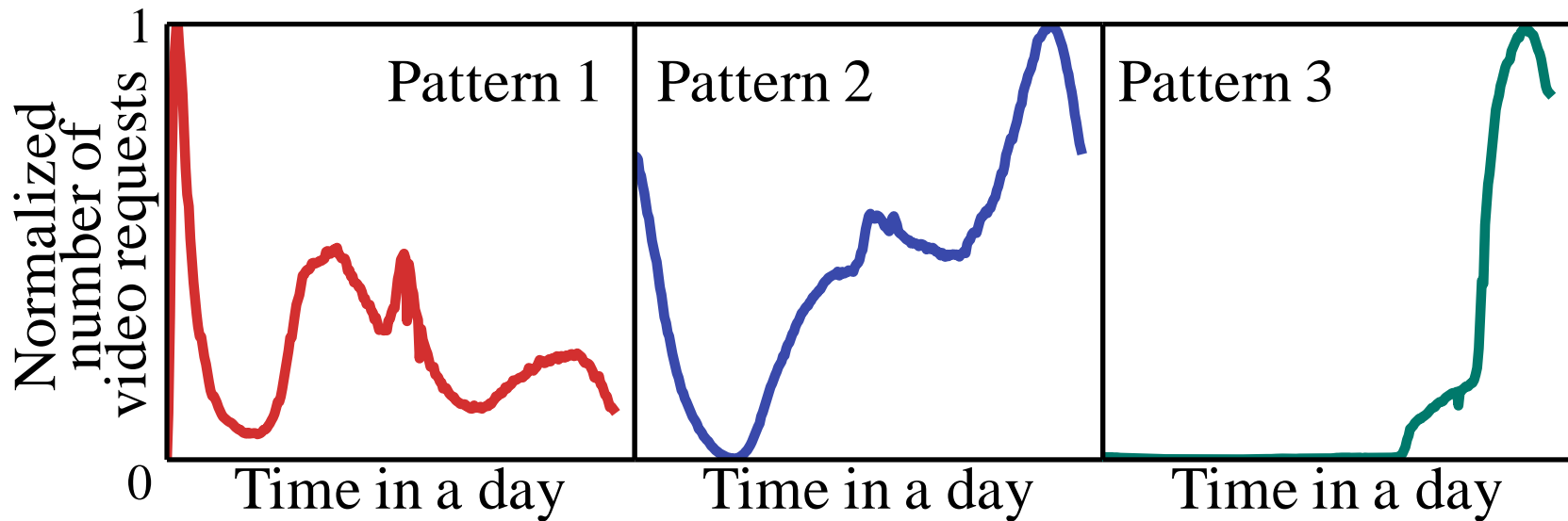


# Which video should be **proactively** pushed?

- First, data analysis & preprocessing;
- Then, select features & learn parameters by prediction (neural) network;
- Finally, push replicas to the appropriate edge devices based on the learning results.



# Three patterns of the number of playbacks



## Potential features (Contextual)

- # of playbacks, # of replicas in the P2P network in the previous timestamps.
- The # of playbacks during the peak hours of the previous day.
- The time since the video was released.
- *What about the new videos?*
- *Are these features enough?*

# Potential features (Semantic)

**全境通告** ▶ 立即播放

电视剧 12集全

地区: 美剧 **导演: Matt Nix** **类型: 罪案剧/剧情/都市** 语言: 英语 电视台: 其它 年份: 2018

**Genre tags**

**Score from analysts / audiences**  
391.9万播放 **7.0** 分

**Creator / Director tags** **Actor / Actress tags**

ho Runs the Streets of New Orleans》得到灵感。背景为在一个破产、奄奄一息的城市中，一个神秘、科技界的  
陷麻烦的警局，设立一支 ... [展开](#) ✓

**剧集概览** 剧情讨论 相关视频

**剧集列表 (共12集)** 数字选集 图文选集

**1-12**

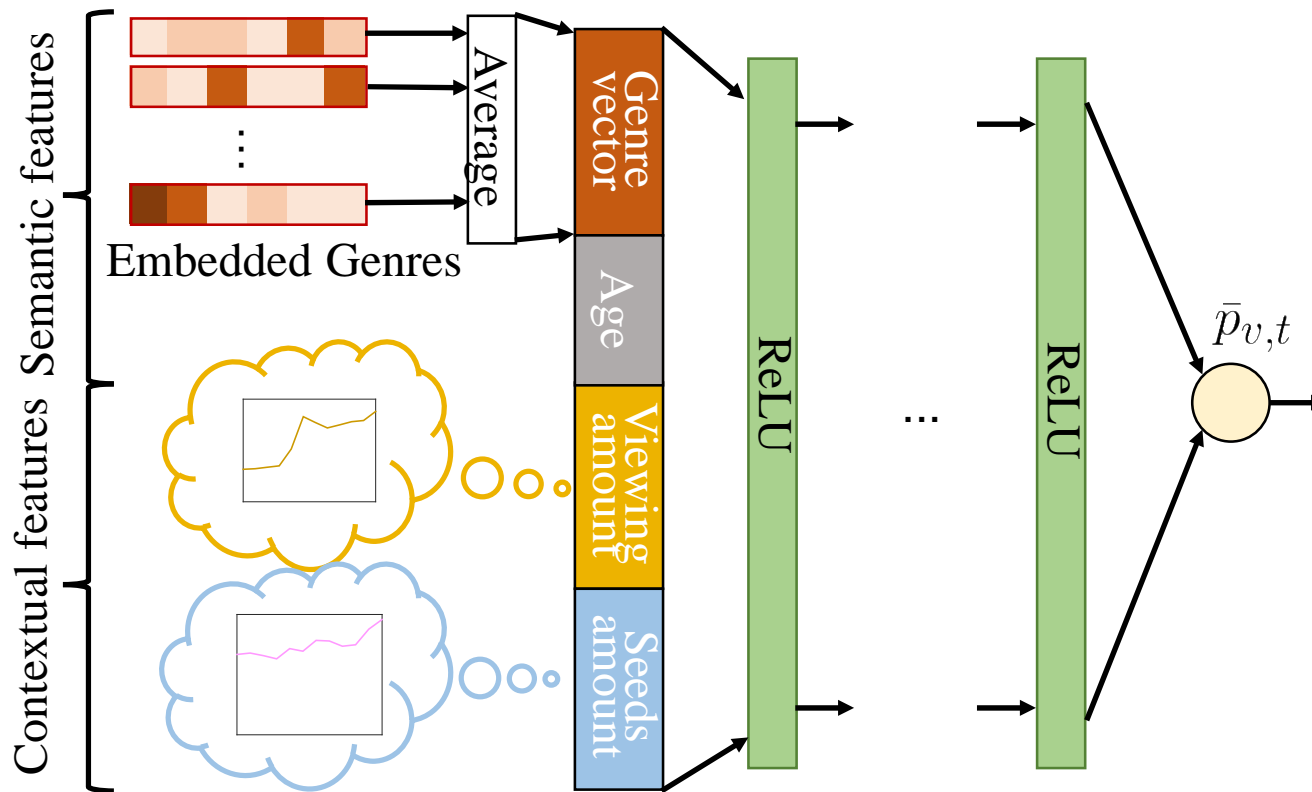
**第1集** 43:35 **第2集** 40:38 **第3集** 42:04 **第4集** 40:11 **第5集** 40:11

**演职员表**

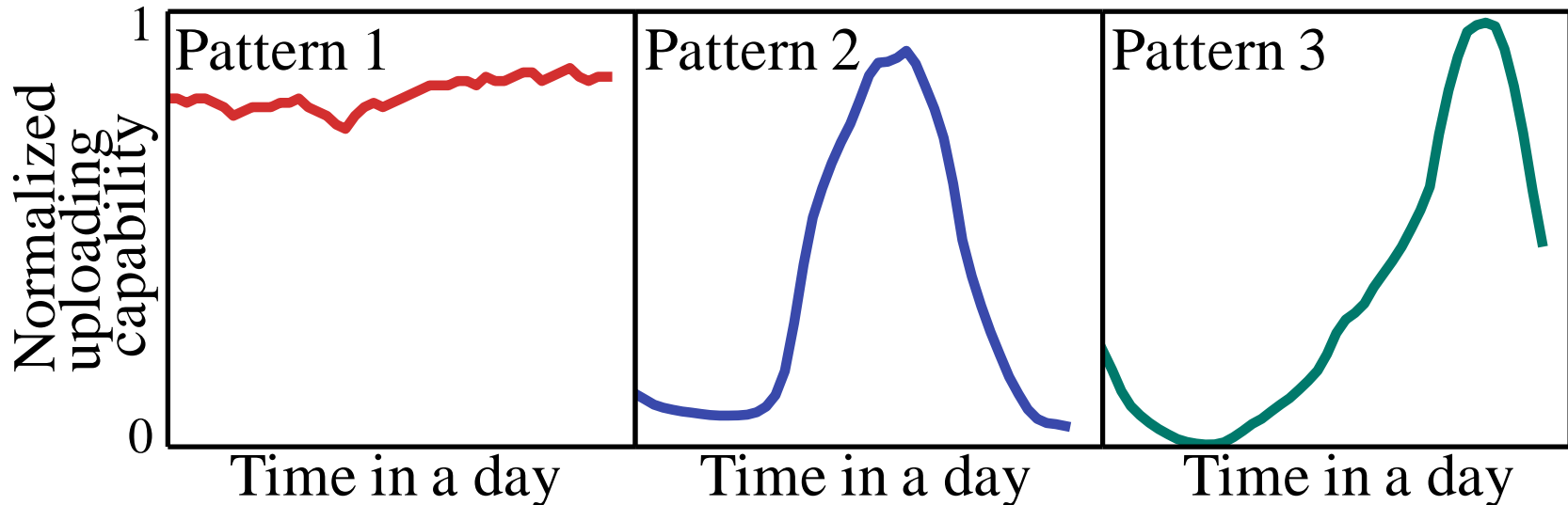
**贾斯汀·柯克** 饰 Justin Kirk **娜塔丽·马...** 饰 Theresa ...

# Deep learning helps

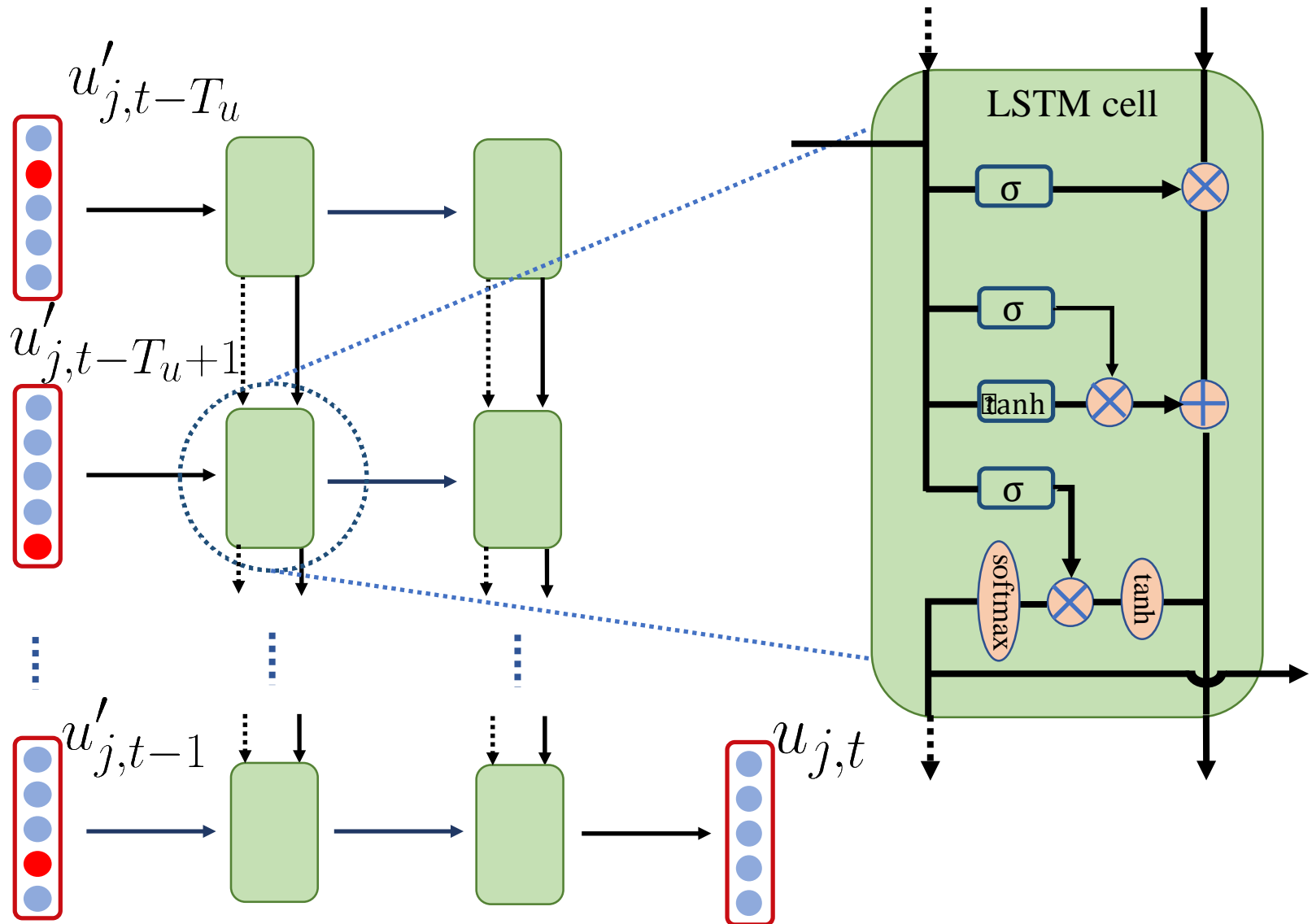
- Dimensionality reduction, training, prediction



# Three patterns of the edge devices' uploading capability



# Time series prediction of users' uploading capabilities

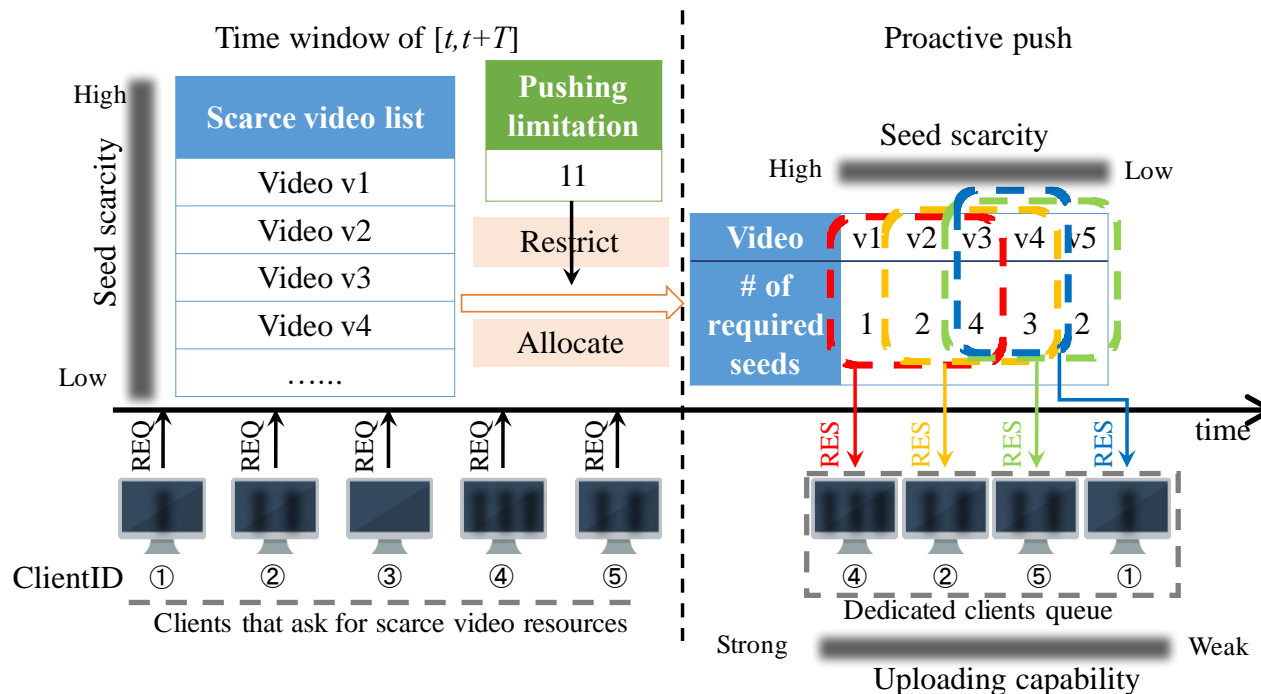




# How to push the replicas

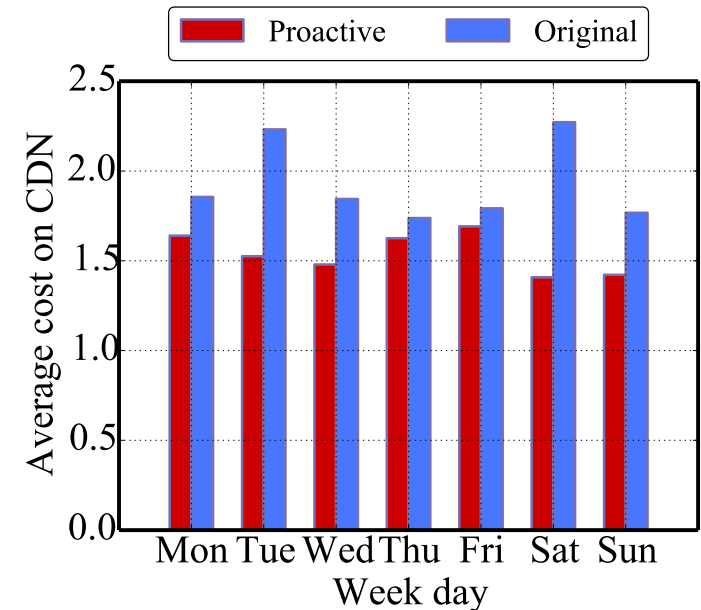
- Replicas of the videos suffering from poor P2P network efficiency should be pushed to clients with strong uploading capability.

将未来很大可能流行度高的内容推送给上传能力强的节点

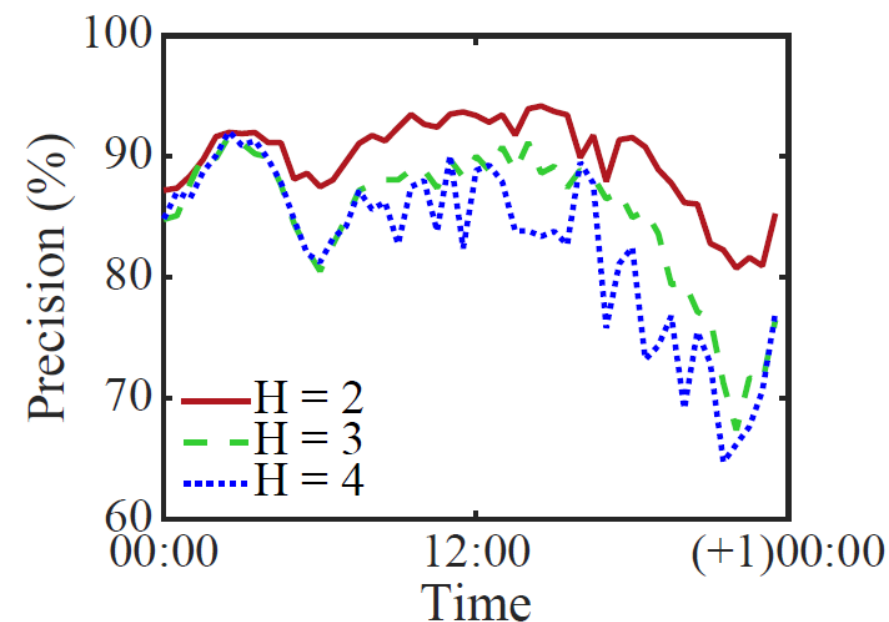


# Pilot deployment

- Original: Hybrid CDN-P2P with smart routers and **reactive push** mechanism.
- Deployment on 2 tracker servers of iQIYI, covering about 2 million users during the peak hours at night, and about 20,000 videos.
- We compute the cost for the compensation data charged by the peak bandwidth consumption.

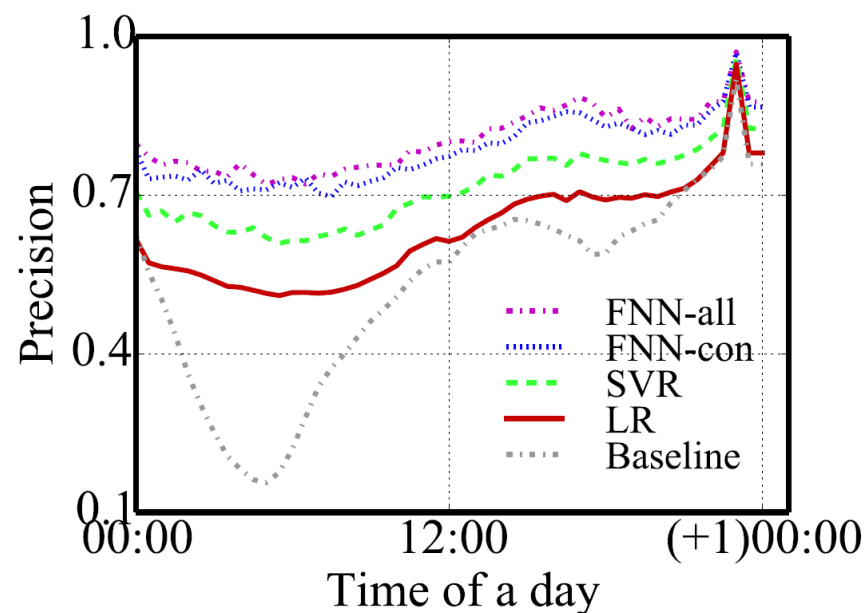


# 晚高峰热门视频资源需求量预测准确率



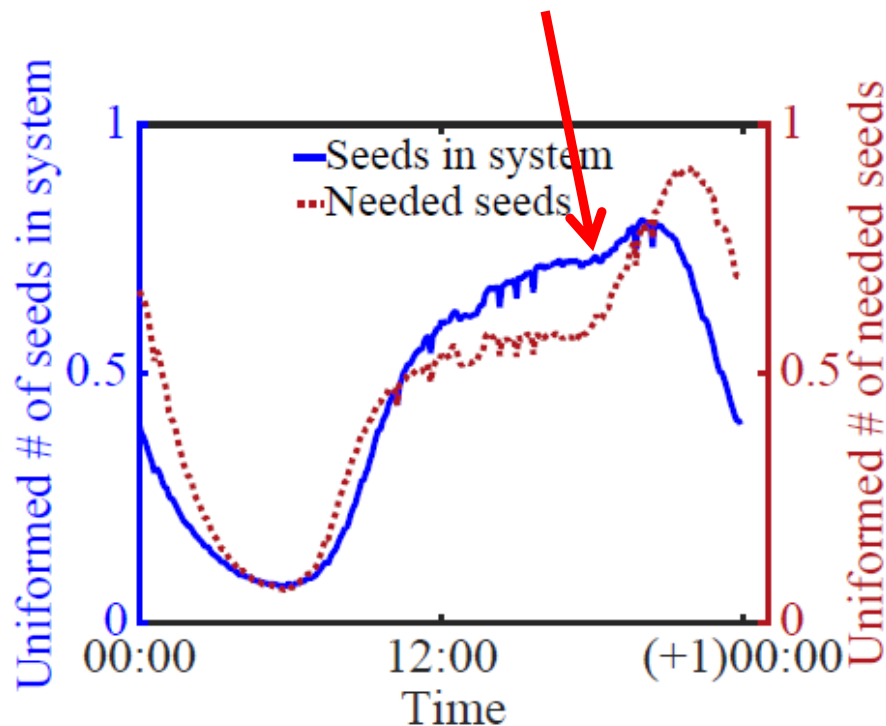
**H=2**

**用前两个小时的数据进行预测**



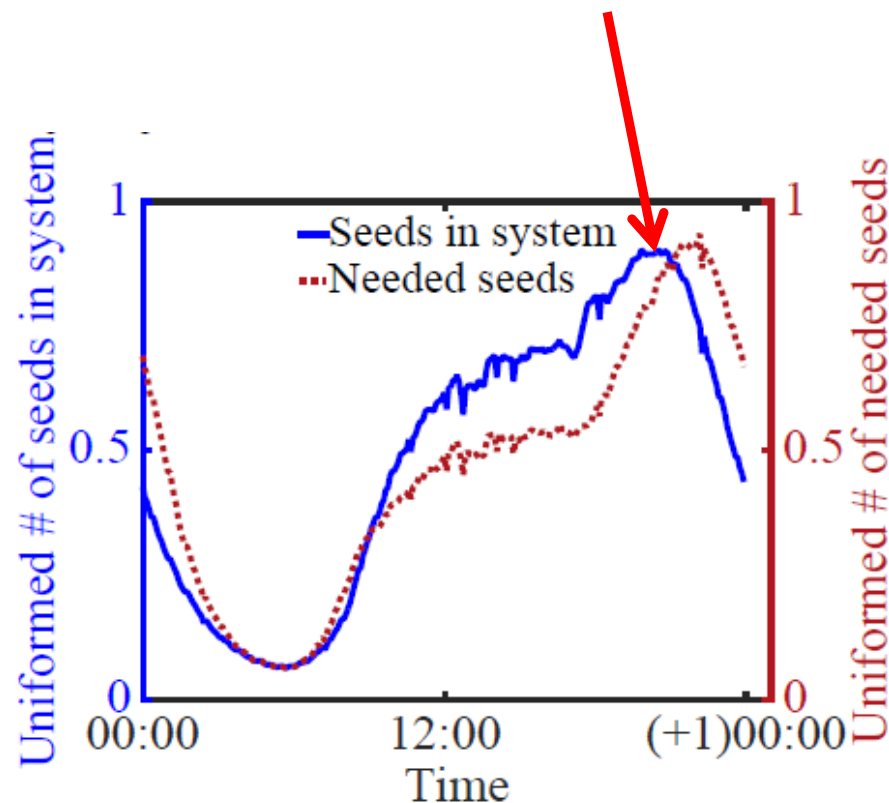
**FNN的预测准确率领先其他方法**

# 晚高峰热门视频资源数量提高 (缓解40%)



(a) Reactive mechanism.

**Without prediction**



(b) Proactive mechanism.

**With prediction**

# Conclusion

# Conclusion

## ■ Reactive vs. **proactive** video push

- CDN download + edge/peer transmission
- Reduce bandwidth cost for download from CDN servers

## ■ **Machine-learning** based predictions

- Content **popularity** prediction
- **Uploading capability** prediction

any  
questions?

Thanks