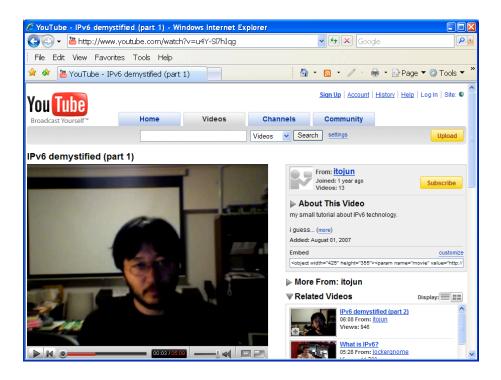
### P2P Live Internet Video

Keith W. Ross Professor of Computer Science Polytechnic University, Brooklyn

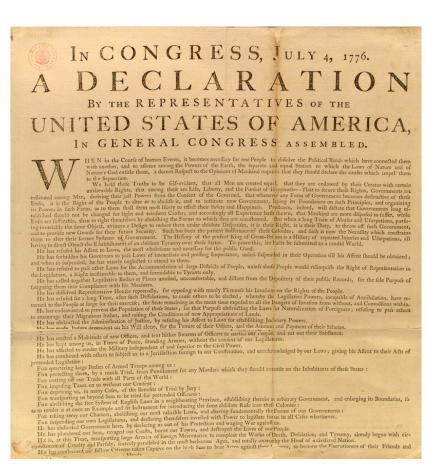
#### Internet Video





Should it be called IPTV?

## We the people want:



- to share our video clips
- & our live video feeds
- with millions of users
- at high resolution
- searchable
- at low cost

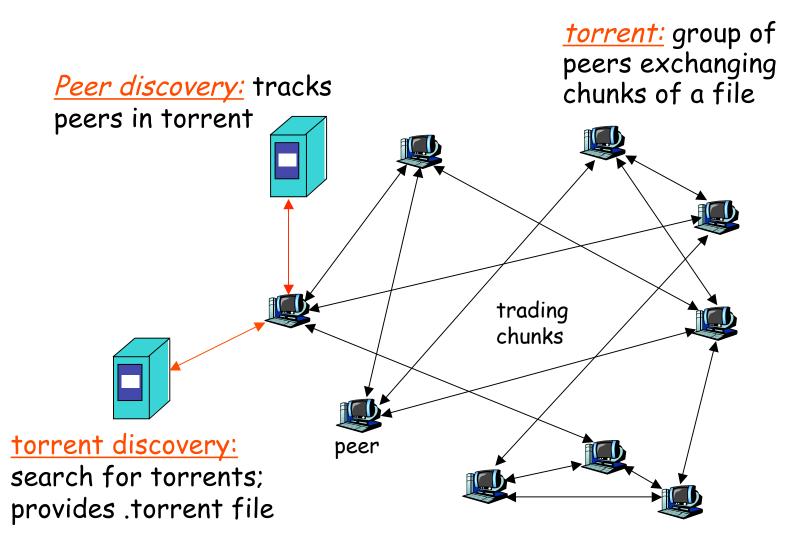
Solution: P2P!

#### P2P Live Video

- Major sporting events
- Presidential debates
- · Little league baseball games
- Political demonstrations
- · A day in Waldo's life

How do we make it happen?

# Lessons Learned from the BitTorrent Ecosystem



## 50+ client implementations













# Dozen public trackers & open-source trackers







#### Dozens of torrent search sites





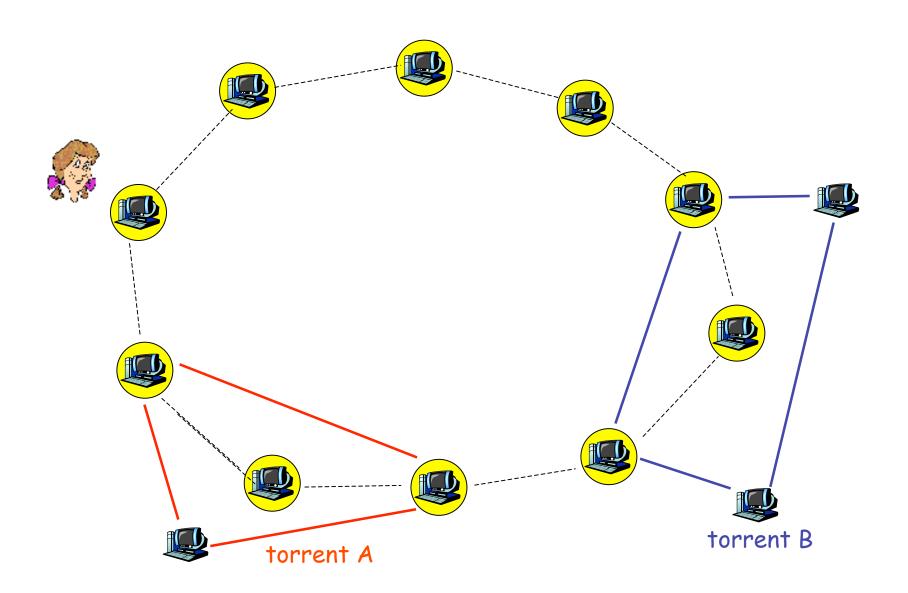


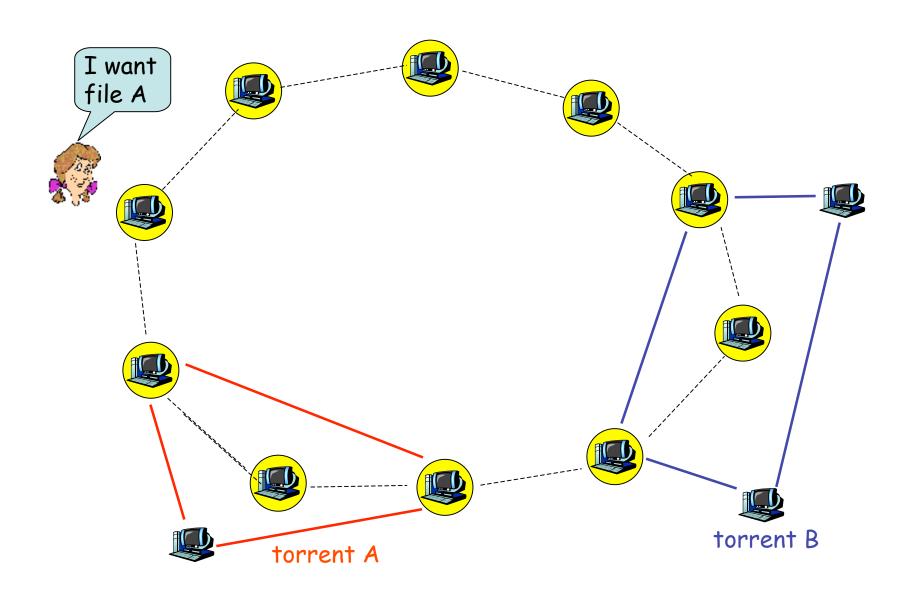


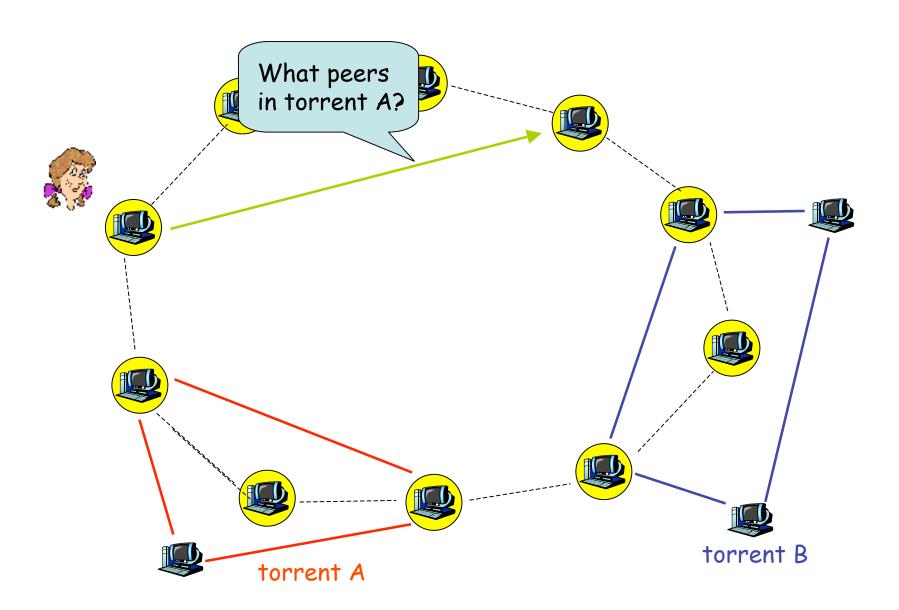


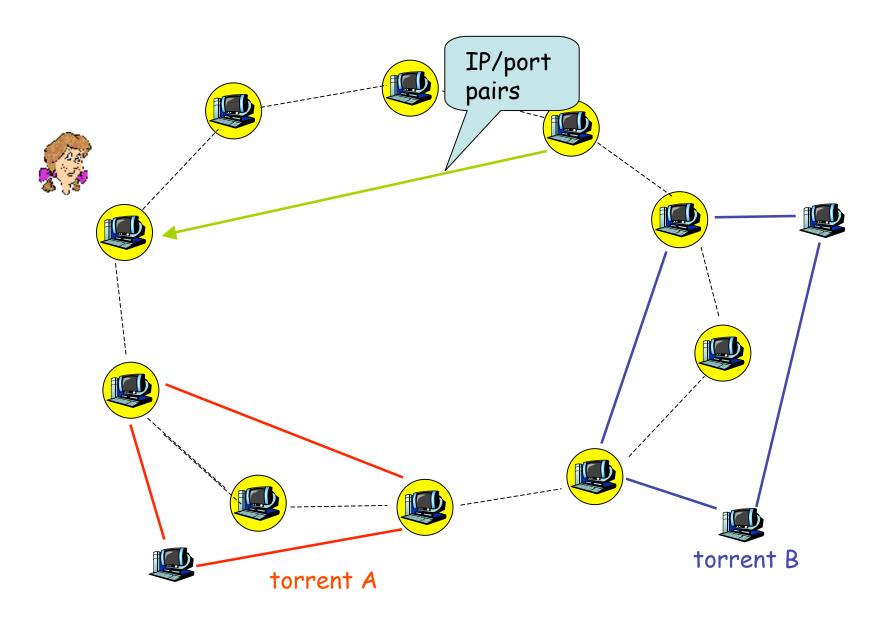


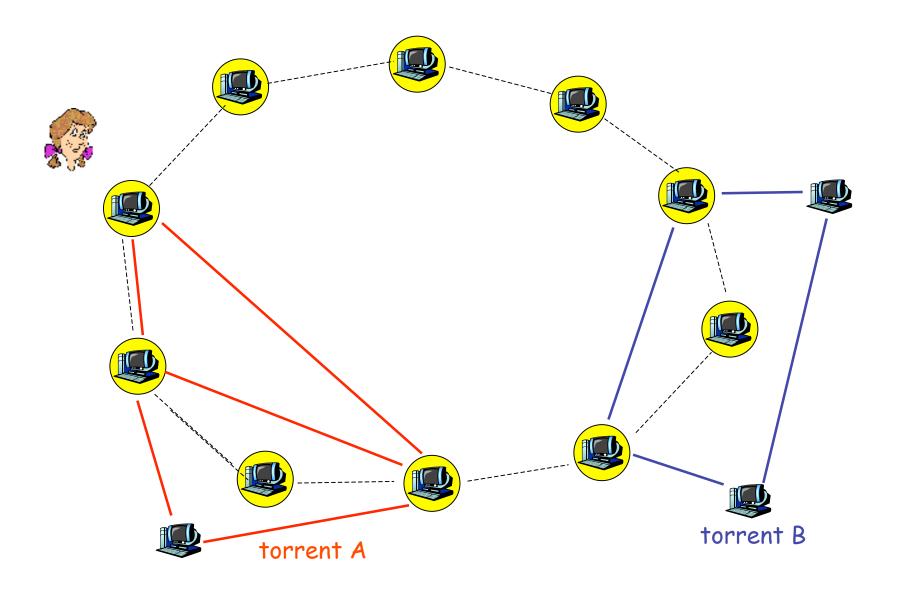












# Evolving BT Ecosystem

- 5-10 million users
- Peer exchange (gossiping)
- Private torrents
  - Invitations
  - Psswd protected

- Seeding algorithms
  - Fastest downloaders
  - Round-robin
- Broadcatching
  - RSS feeds
- Interdiction companies
  - Decoy, leecher, seed attacks

#### BitTorrent: Incentive

- Torrent as whole benefits when all peers upload
- Question: What is the incentive to upload at higher rate?
- · Answer: To get file faster
- · Implementation: Tit-for-tat

## P2P Live Streaming: Many Incompatible Systems



ppStream



Coolstreaming





## Eco-system for Live P2P Video?

- Common protocol
  - e.g. the P2PP Internet Draft (Basset, Schulzrinne, Matuszewski)
  - Messages and message formats, NAT traversal, enrollment and authentication server, ...
- · Incentive mechanism needed

## Incentives for Live Streaming

- Why upload at all?
  - No incentives in existing deployments
- Is tit-for-tat a sufficient incentive?
  - No! Why contribute more upload bandwidth if you're receiving the video at the full rate?
- · Main idea:
  - If you upload more, you get better quality.

Joint work with Zhengye Liu, Shiv Panwar, Yao Wang

## Layered Video w/ Tit-for-Tat

 Generate multiple layers, each divided into layer chunks (LCs)

```
      Layer 3
      LC31
      LC32
      LC33
      LC34

      Layer 2
      LC21
      LC22
      LC23
      LC24

      Layer 1
      LC11
      LC12
      LC13
      LC14
```

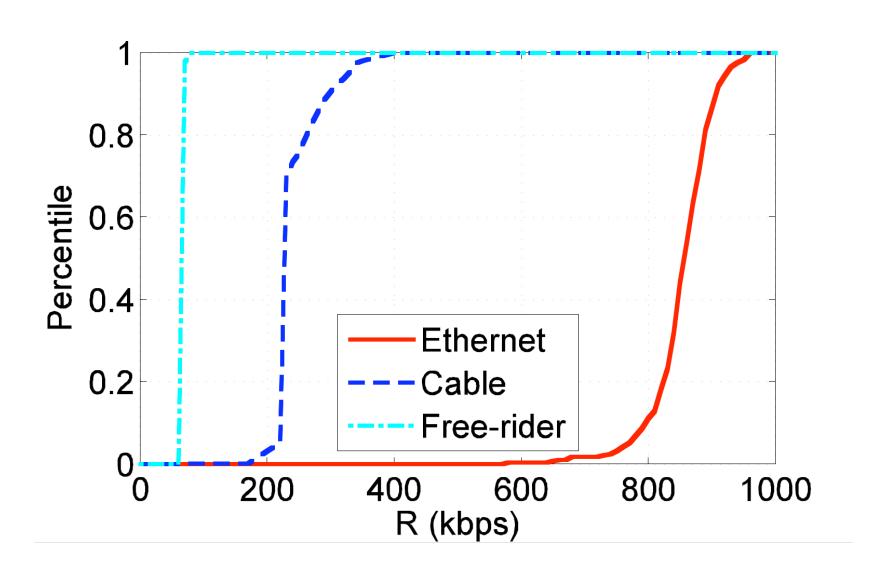
- Exchange LCs
- Measure download rates from neighbors
- Reciprocate to neighbors based on their contributions

## Performance Study Setup

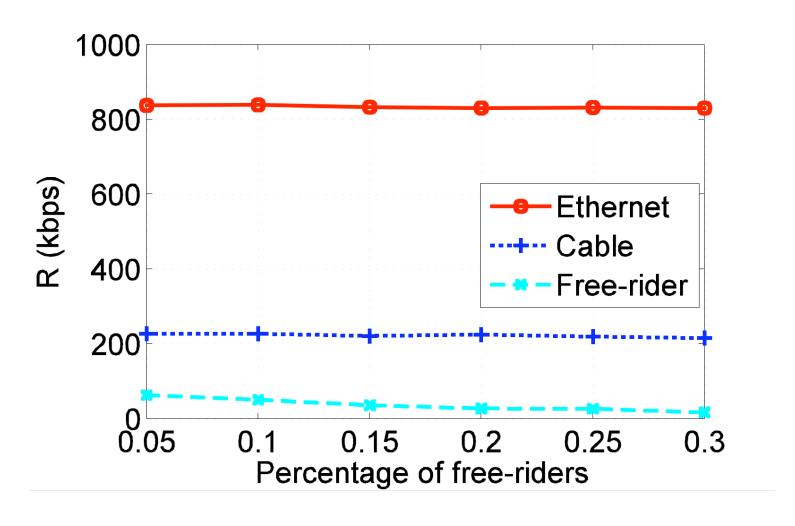
#### Peers

- Ethernet peer: 1000 kbps; cable peer: 300 kbps; free-rider: 0 kbps
- Video
  - 20 layers, with each layer having a rate of 50 kbps

#### Differentiated Service



## Free-Riding



## Conclusion

- BitTorrent has been an enormous success for open protocols.
- Can we replicate with live P2P streaming?
- And with P2P VoD?
- As with BitTorrent, need common protocol and incentive mechanism

## Thank You!

#### IN CONGRESS, JULY 4, 1776. ADECLARATION BY THE REPRESENTATIVES OF THE

#### UNITED STATES OF AMERICA.

IN GENERAL CONGRESS ASSEMBLED.

HEN in the Course of human Events, it becomes necessary for one People to dissolve the Political Bands which have connected them with another, and to assume among the Powers of the Earth, the separate and equal Seation should be which the Laws of Nature and of Nature's Code entitle them, a decent Repécte to the Opinions of Mankan equits that they should declare the causes which impel them with another, and to affame among the Powers of the Earth, the feparate and equal Station to which the Laws of Nature and of Nature's God entitle them, a decent Refrect to the Opinions of Mankind requires that they should declare the causes which impel them to the Separation.

We hold these Truths to be self-evident, that all Men are created equal, that they are endowed by their Creator with certain unlienable Rights, that among these are Life, Liberty, and the Pursiti of Huppiness—That to secure these Rights, Governments are inflituted among Men, detriving their just Powers in the Consent of the Governed, that whenever any Form of Governments of the Ends, it is the Right of the People to alter or to abolish it, and to inflitute new Government, laying its Foundation on such Principles, and organizing to Powers in such them is not them shall few month likely to effect their Safety and Happines, Pradence, indeed, will dictate that Government long established should not be changed for light and transfert Causes; and accordingly all Experience hath shewn, that Mankind are more disposed to self-received them under abolute Desposition, it is their Right, it is their Duty, to throw off such Government long established should be a self-received them under abolute Desposition, it is their Right, it is their Duty, to throw off such Government to alter their former Systems of Government. The History of the present King of Greet-Brit is an is a History of repeated lapines and Unarpations, all having in direct Object the Etablishment of an abolute Transp over these States. To prove this, let Facts be dubmitted to a candid World.

He has forbidden his Governors to pake Laws of immediate and pressing Importance, unless suspense of human from which when so submitted to a candid World.

He has forbidden his Governors to pake Laws of immediate and pressing Importance, unless such such as a submitted to a candid World.

He has reduced to the Laws for the Accommodation of large Districts of People, unless those People would relinq

retended Legislation:

For quartering large Bodies of Armed Troops among us:
For quartering large Bodies of Armed Troops among us:
For protecting them, by a mock Trial, from Punishment for any Murders which they should commit on the Inhabitants of these States:
For protecting them, by a mock Trial, from Punishment for any Murders which they should commit on the Inhabitants of the States:
For impring Taxes on us without our Consent:
For impring Taxes on us without our Consent:

For impoling Taxes on us without our Confent:

For depriving us, in many Cafes, of the Benefits of Trial by Jury:

For transforting us beyond Seas to be tried for pretended Offence:

For transforting us beyond Seas to be tried for pretended Offence:

For abolithing the free System of English Laws in a neighbouring Province, establishing therein as arbitrary Government, and enlarging its Boundaries, for the state of th