Modeling, Analysis and Improvement for BitTorrent-Like File Sharing Networks

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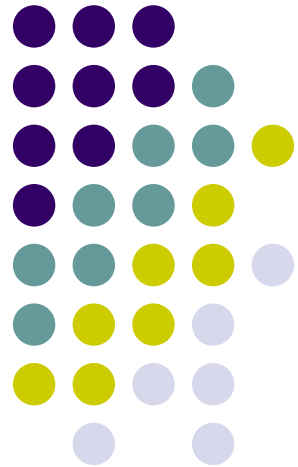
2006/10/13

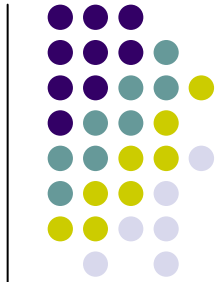
INFOCOM 2006



Outline

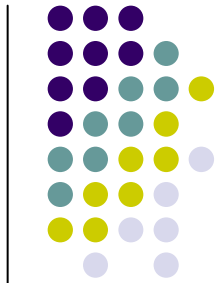
- Introduction
- Modeling and analysis for peer distribution
- File availability and incentive mechanism
- Experiments
- Conclusion

Introduction



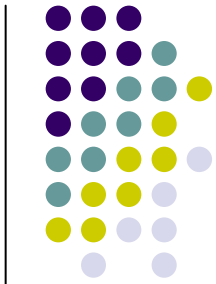
- In this paper, a simple mathematical model is presented for studying the performance of the BitTorrent file sharing system.
  - The distribution of the peers with different states of the download job completedness
  - The file availability and the dying process of BT
  - An incentive peer selection strategy

The download efficiency



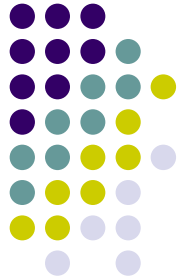
- Client/server model: the download efficiency depends mainly on the server's capacity and the underlying network.
- BitTorrent: the probability of successfully finding a proper upload/download partner also determines a peer's download rate.

File availability and incentives to improve the system's stability



- The lifetime of a BT network is the period in which it could provide a complete file .
- If the shares kept by the peers are incomplete, we call the system dead.
- The phase that the system is vulnerable to die is called the dying process of the system.

File availability and incentives to improve the system's stability



- BT adopts tit-for-tat strategy to finish the download as fast as possible.
- However, when the system is in the dying process, another objective besides the download rate for a peer is the possibility that it could finish the download.

Modeling and analysis for peer distribution

- The states of $S_0, S_1 \ldots S_{N-1}$ represent the peers with different portions of the file respectively, and S_N is the state for seeds.

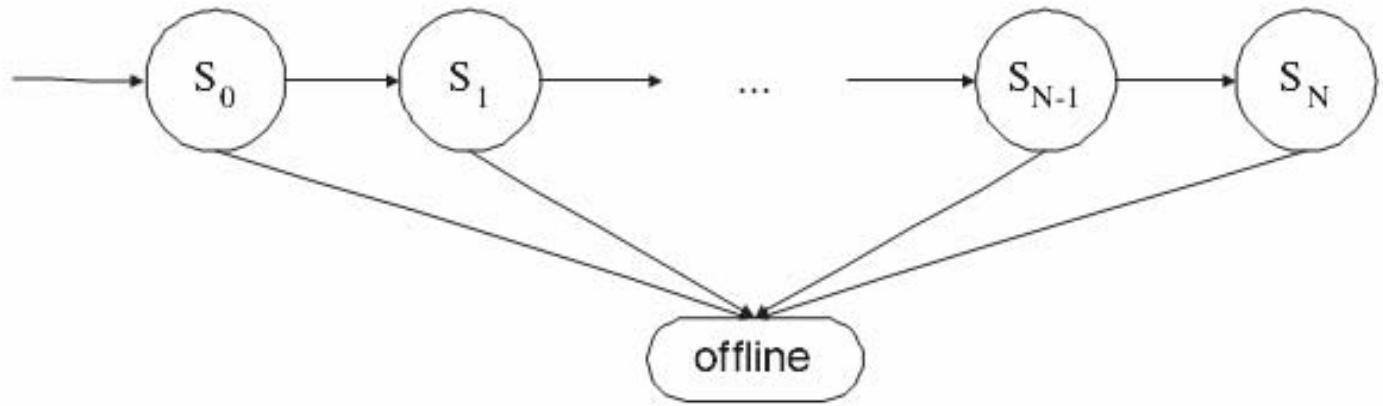


Fig. 1. The model for the BitTorrent file sharing system

Parameters

- N: the total number of states in the model;
- $x_0(t), x_1(t), ..., x_{N-1}(t)$: the number of the download peers in the states of S_0, S_1, ..., S_{N-1} respectively;
- $y(t)$: the number of seeds;
- μ: the average upload rate for a peer, including the seeds;
- λ: the arrival rate of the new download peers;
- γ: the departure rate of the seeds;
- θ: the abort rate of the download peers;
- $\eta_{i,j}$: the efficiency of exchanging shares between a peer at the state of S_i and a peer at the state of S_j.

- r(*state1*,*state2*) denotes the transfer rate of the peers from *state1* to *state2*

$$r(S_N, offline) = \gamma y(t)$$

$$r(S_{N-1}, S_N) = \mu y(t) \times \frac{x_{N-1}(t)}{\sum_{j=0}^{N-1} x_j(t)} + \frac{x_{N-1}(t)}{\sum_{j=0}^{N-1} x_j(t)} \times \mu \sum_{k=0}^{N-1} x_k(t) \times \eta_{N-1,k}$$

$$r(S_0, S_1) = \mu y(t) \times \frac{x_0(t)}{\sum_{j=0}^{N-1} x_j(t)} + \frac{x_0(t)}{\sum_{j=0}^{N-1} x_j(t)} \times \mu \sum_{k=0}^{N-1} x_k(t) \times \eta_{0,k}$$

$$r(S_0) = \lambda$$

$$r(S_i, offline) = \theta x_i(t), i = 0, 1, ..., N-1$$

- r (the departure rate of the seeds) -> ∞
- θ (the abort rate of the download peers) =0
- The rate of the flow out of a state = the rate of the flow into this state.

$$x_i = \frac{x_0(2N-1)}{(2N-2i-1)(2i+1)}$$

$$x_0 = \frac{\lambda}{\mu} \times \frac{16N^4}{(2N-1)} \times \sum_{j=0}^{N-1} \frac{1}{(2N-2j-1)(2j+1)}$$

λ : arrival rate of the new download peers

μ : the average upload rate for a peer, including the seeds

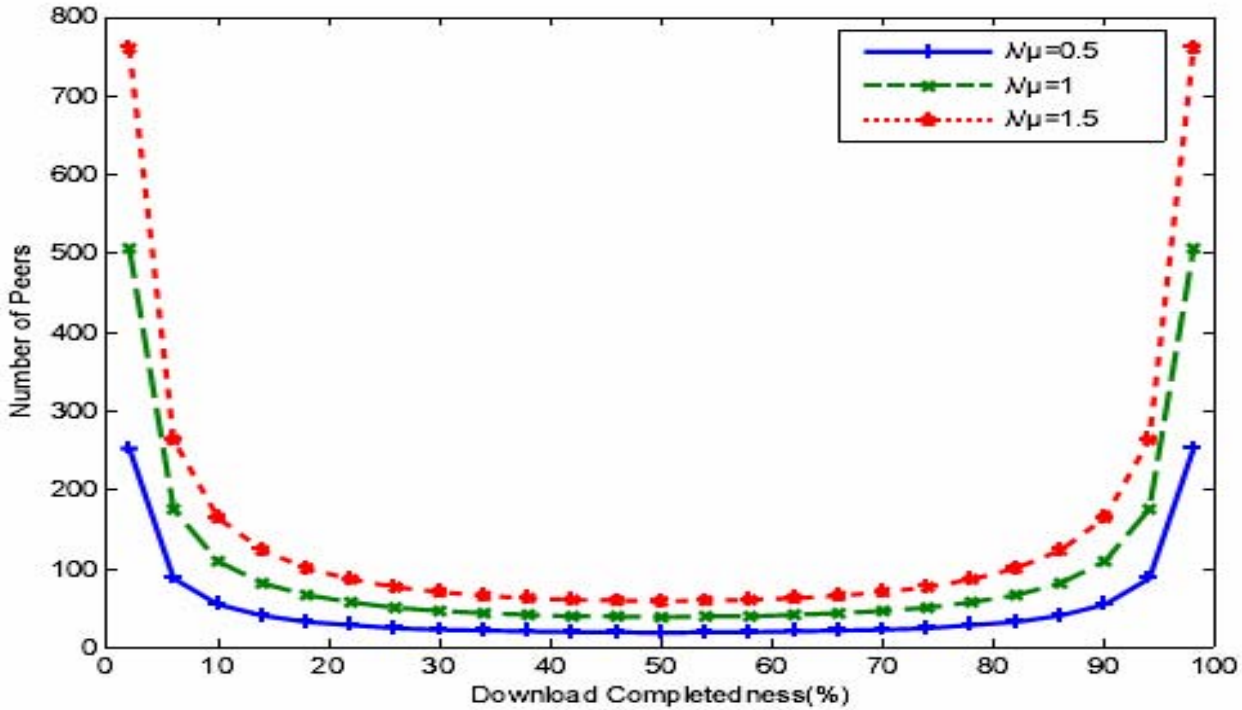
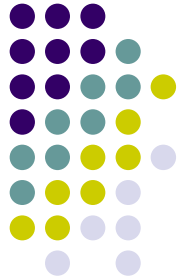


Fig. 2. Peer distribution in the stable state, without the seeds departure and the download peers aborting



- The peer distribution follows a U-shaped curve.
- By altering the parameters of λ and μ, it only changes the number of the peers at each state.
- The relationship among the numbers of the peers with different download completedness will not be changed.

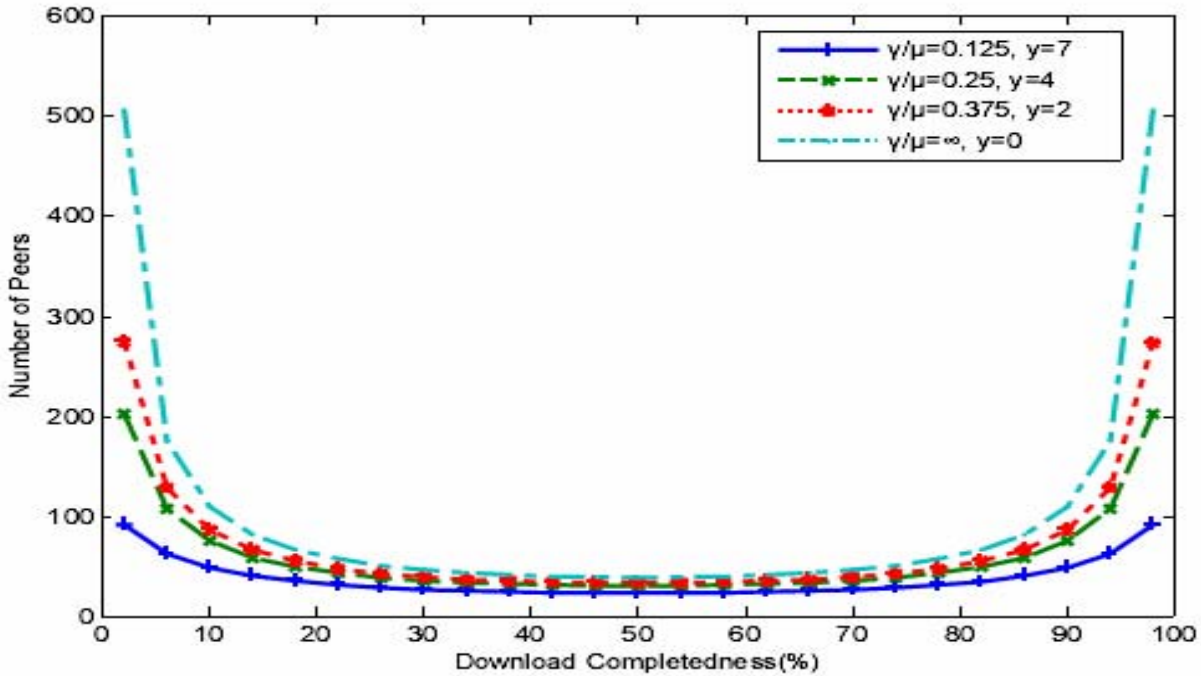


Fig. 3. Peer distribution in the stable state, influenced by the departure rate of the seeds

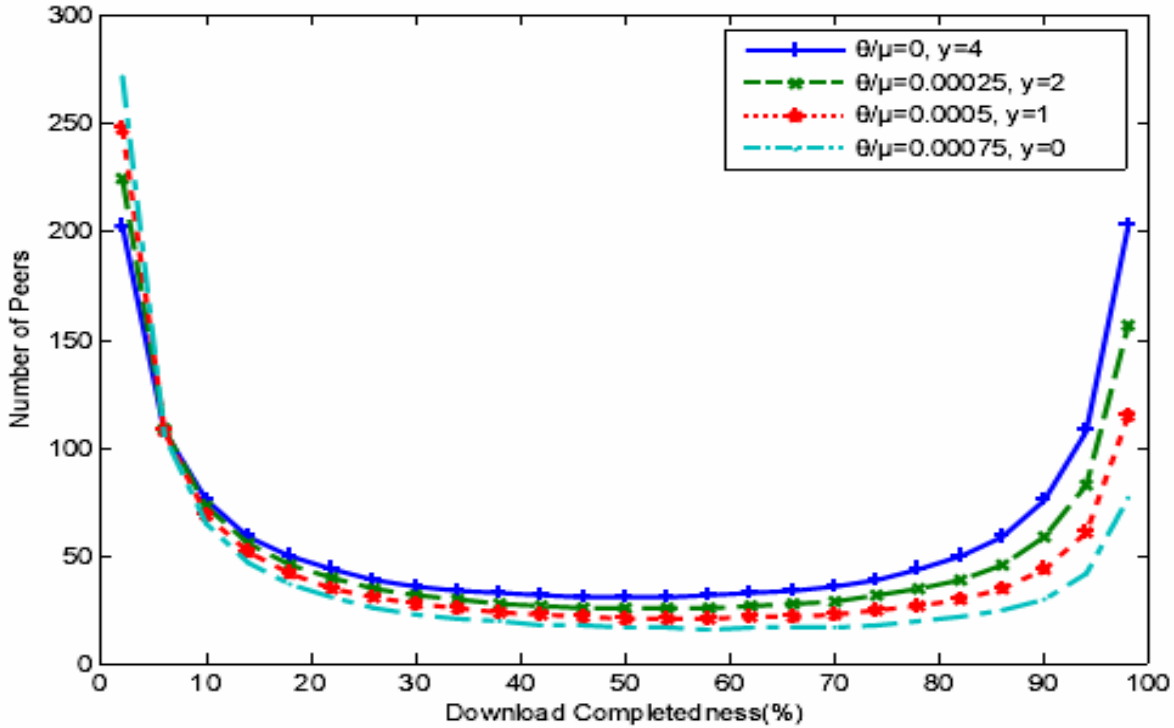
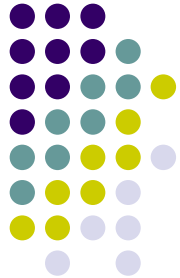
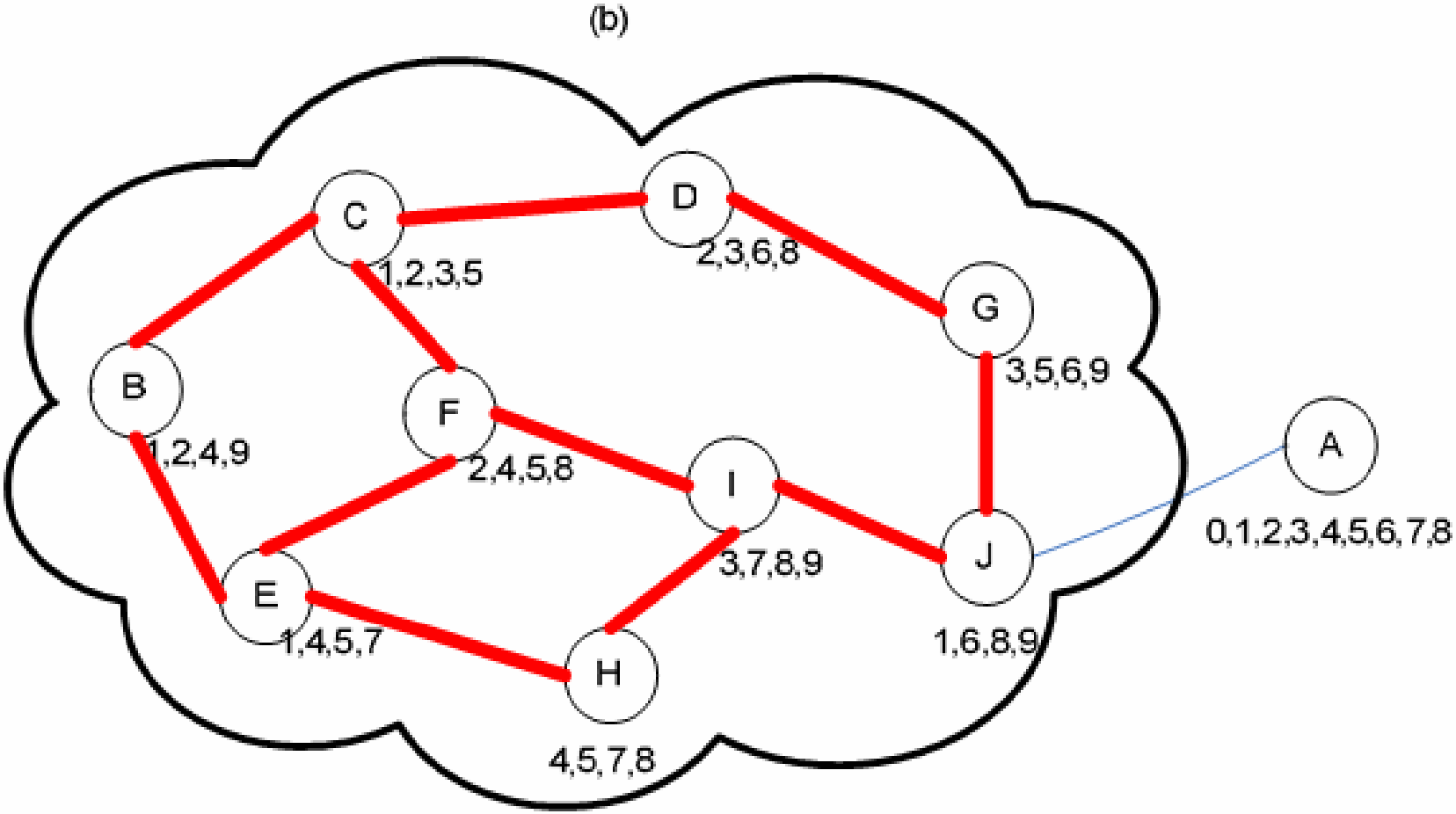


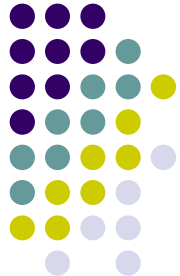
Fig. 4. Peer distribution in the stable state, influenced by the abort rate of the download peers

File availability and incentive mechanism



- When the system is in the dying process, another objective besides the download rate for a peer is the possibility that it could finish the download.


(b)
C
D
1,2,3,5
2,3,6,8
G
3,5,6,9
B
F
1,2,4,9
2,4,5,8
I
A
0,1,2,3,4,5,6,7,8
3,7,8,9
J
E
1,4,5,7
1,6,8,9
H
4,5,7,8



- To keep the peers with large portions of the shares online.
- The tradeoff between the file availability and the system’s efficiency should be noticed.

Incentive mechanism for the dying process

- A peer p_i : m_i shares, a upload rate of μ_i
- *Neighbor peer* p_j : m_j shares, a upload rate of μ_j, and a download rate of d_j

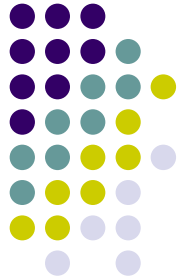
$$T_1 = \frac{m_j \frac{M - m_i}{M}}{\mu_j} \qquad T_2 = \frac{M - m_j}{d_j} + \Delta T.$$

- T1 is the estimated period of time that p_j could finish uploading all the shares p_i needs.
- T2 is the estimated time that p_j will be online.
- ΔT is the average service time of the seeds.

- For the neighbor p_j , p_i willcalculate its potintial gain as:

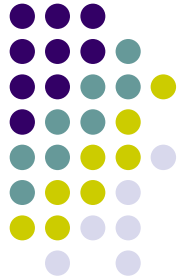
$$g_j = \mu_j \sum_{i=0}^{\lceil \frac{T}{t_{int}} \rceil} \alpha^i$$

- α = tradeoff factor [0,1)
- T= min(T1,T2)
- T_{int} is the execution interval of the peer selection strategy



- In this mechanism, peer p_i will choose p_j to upload when the gain g_j is among the highest four gains.

Experiments



- New arrival rate 0.5/min
- Seed depart 0.007/min
- Abort rate 0.001/min
- Each peer is allowed to obtain one share from an unchoked connection per minute.

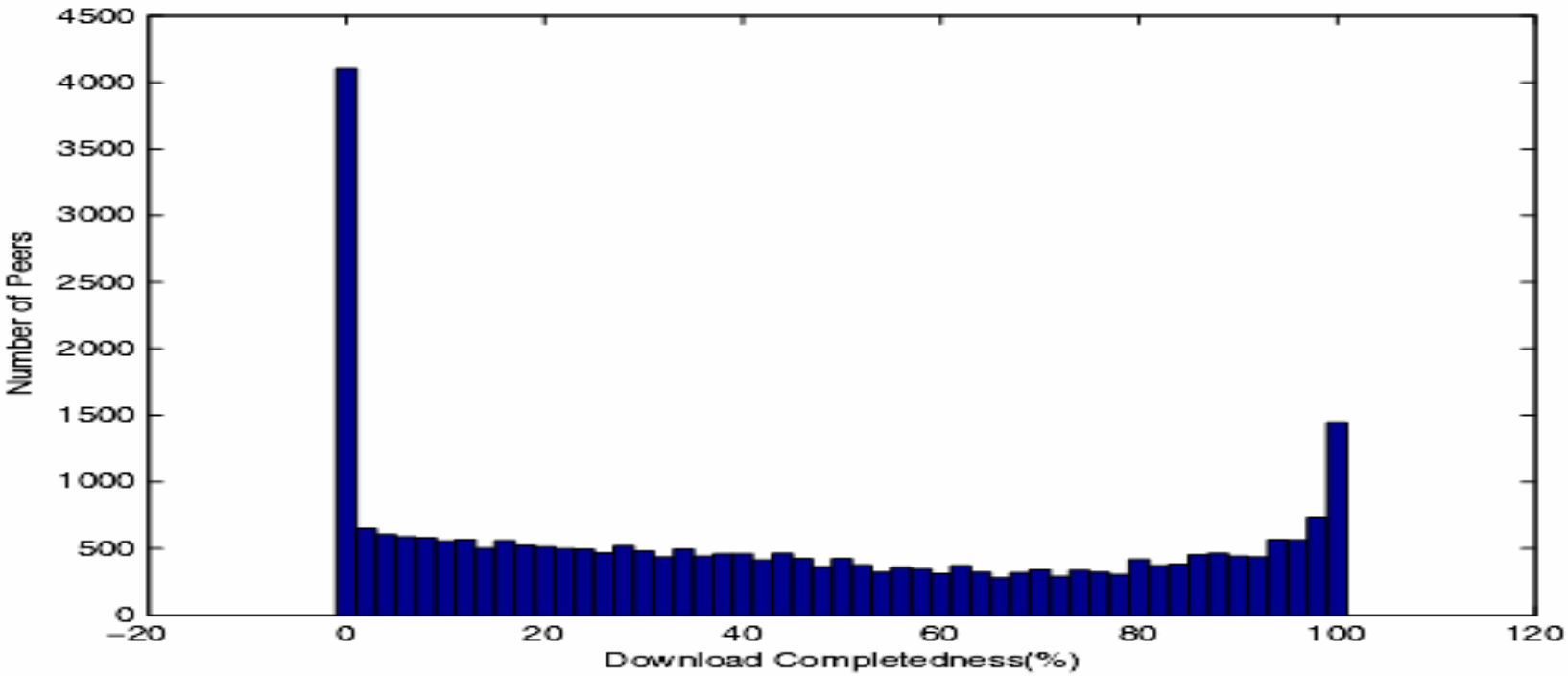
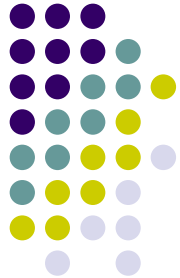


Fig. 7. Aggregated peer distribution from the simulation



- the measurement of the peer distribution based on the data obtained from the real world BT application

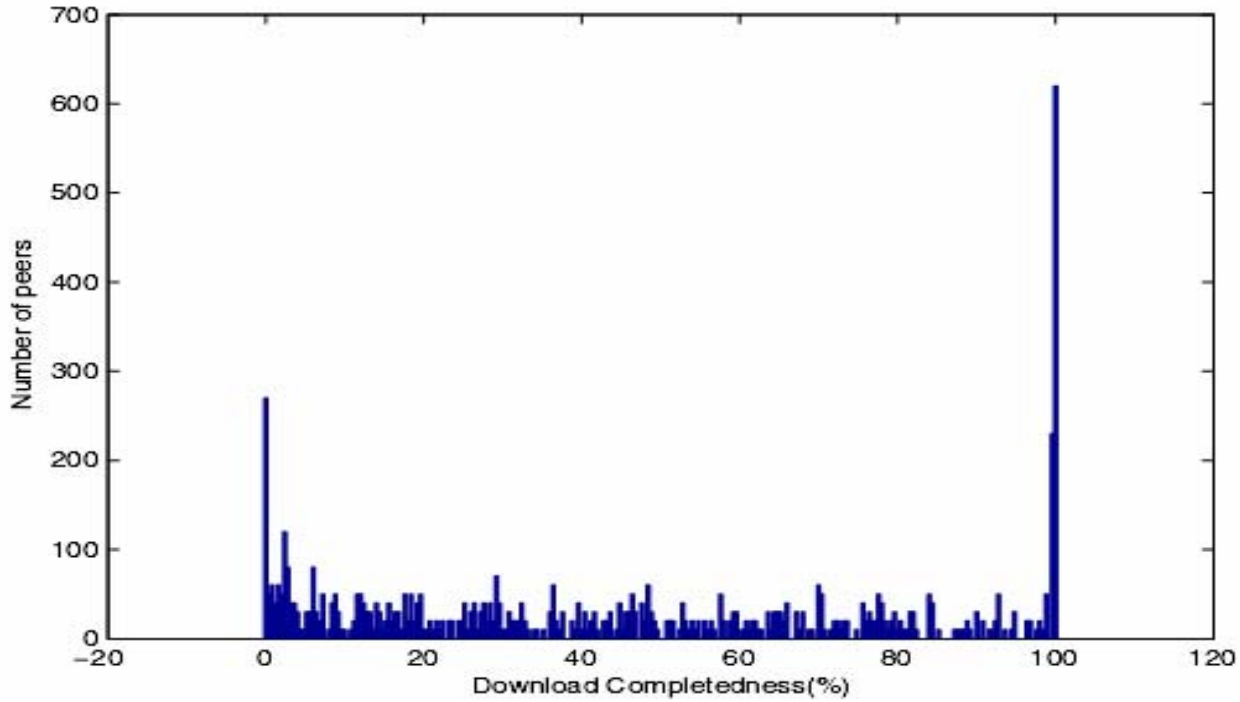
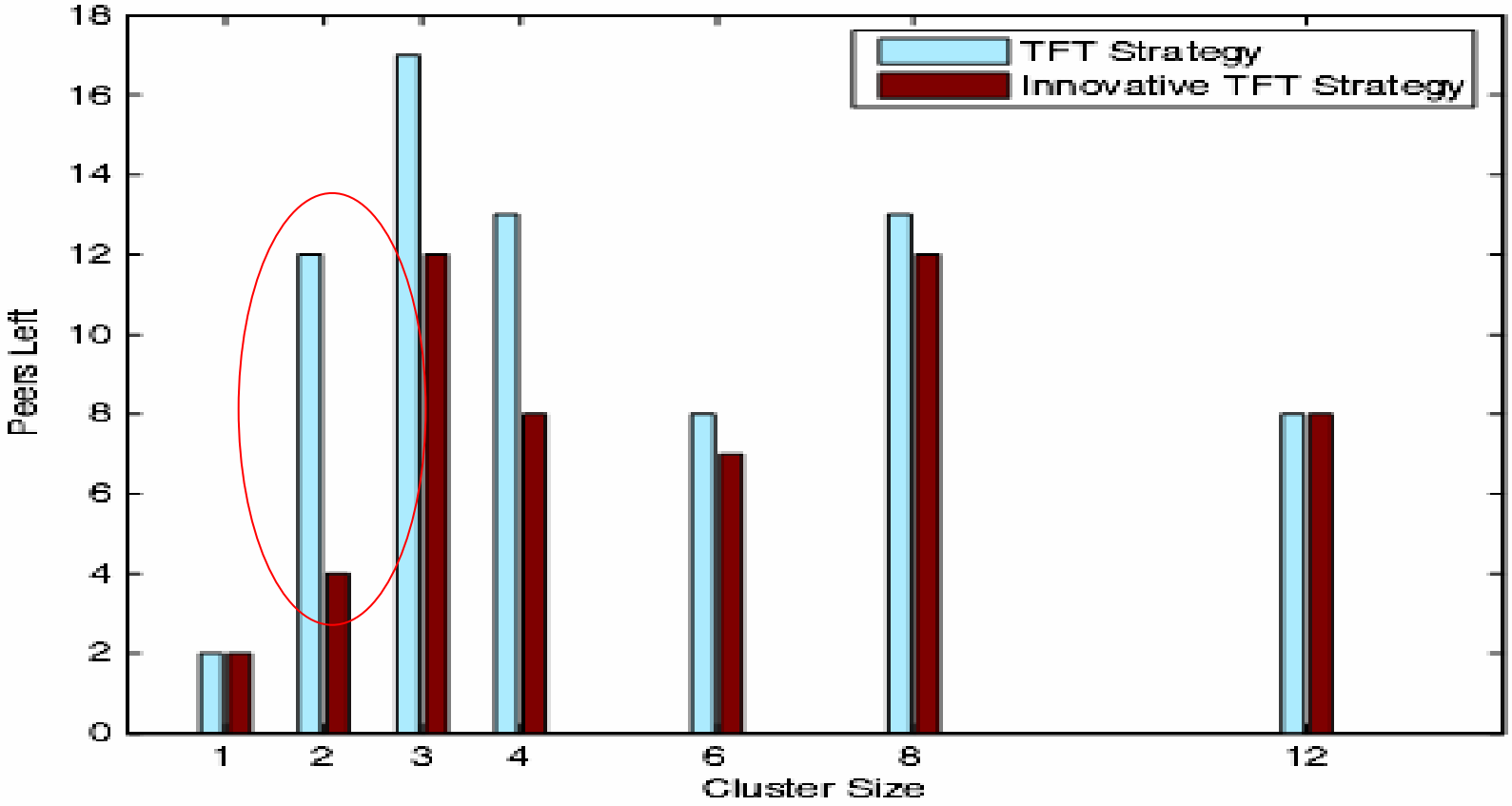


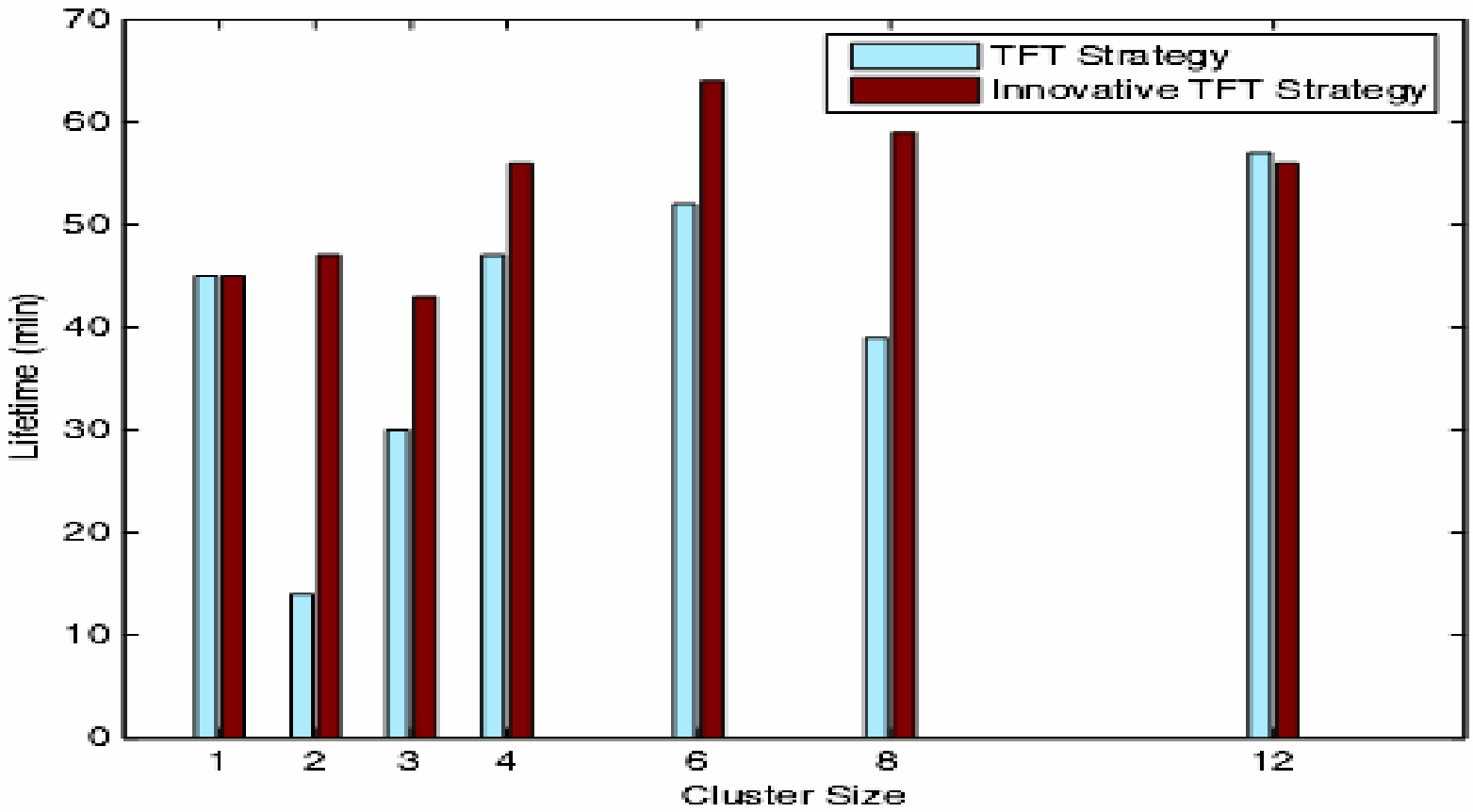
Fig. 9. Histogram of the download peers with the degrees of job completedness, observed from the real world BitTorrent application

TABLE I

SIMULATION SETTINGS

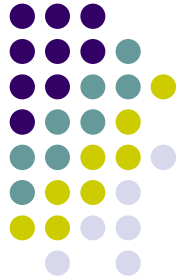
Setting	Peer #	# of Clusters	Completedness for each Cluster
1	24	1	50%
2	24	2	30%, 80%
3	24	3	10%, 43%, 86%
4	24	4	15%, 40%, 65%, 90%
5	24	6	5%, 22%, 39%, 56%, 73%, 90%
6	24	8	4.5%, 17%, 29.5%, 42%, 54.5%, 66%, 78.5%, 90%
7	24	12	8.3%, 16.6%, 25%, 33.3%, 41.6%, 50%, 58.3%, 66.6%, 75%, 83.3%, 91.6%, 99%


TFT Strategy
Innovative TFT Strategy
Peers Left
Cluster Size
0
2
4
6
8
10
12
14
16
18
1
2
3
4
6
8
12

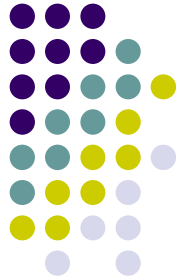

TFT Strategy
Innovative TFT Strategy
Lifetime (min)
Cluster Size
0
10
20
30
40
50
60
70
1
2
3
4
6
8
12

Conclusions

- In this paper, the authors develop a mathematical model to study the behavior of the peers in BT .
- We can find that under the stable state, the distribution of the peers regarding their download job completedness follows a U-shaped curve.



- An innovative TFT peer selection strategy is proposed aiming to improve the system's stability.
- By comparing the two TFT strategies with the simulation, we can find that the innovative strategy helps in preserving the file availability.



Thank you☺