TABLE I

MAPPING BETWEEN THE QUEUING NETWORK MODEL AND THE P2P VOD SYSTEM

A queuing network	A overlay
A node Q_i	A peer p_i
A job	a unit of budget
num. of jobs in a node	a peer's budget
routing probability	probability of budget transfer
num. of routing arrows ending at Q_i	num. of p_i's upstream neighbors
num. of routing arrows heading at Q_i	num. of p_i's downstream neighbors
u_i	p_i's budget average spending in a unit of time
λ_i	p_i's avarage net income of budget in a unit of time

TABLE II

NOTATIONS USED IN THE MODEL

N	num. of peers

λ_i can reflect peer i's upload capacity.

The paper "Condensation in Large Closed Jackson Networks" [1], gives sufficient condition of condenstion in its Theorem 2.2.

a BCMP network is a class of queueing network for which a product form equilibrium distribution exists. It is a significant extension to a Jackson network allowing virtually arbitrary customer routing and service time distributions, subject to particular service disciplines.

The term of "a product form equilibrium distribution" seems to be similar to "factorized steady states" quoted from the paper "Factorized steady states in mass transport models on an arbitrary graph" [2].

The paper [2] offers sufficient and necessary conditions for the "factorized stead states" and argues that "having a factorized steady state opens the door for the study of condensation" and "Thus one should be able to analyze condensation in various geometries or even on scale-free networks". This tells us that even if we don't need to use the result of this paper to get the sufficient and necessary conditions (but, instead, find out the "factorized steady state" based on the assumptions of our specific model), we have more confidence to analyze the condensation once we have the "factorized steady state".

[3] also discusses that if agents based on a relationship topology of scale-free network exchange mass following a Zero Range Process, it is possible to achieve condensation under some conditions.

I also found (but not yet read through) this paper: "Asymptotics and Scalings for Large Closed Product-form Networks via the Central Limit Theorem" [4]. In its abstract, it says "it is shown that some queues can act as bottlenecks, limiting thus the global efficiency of the system". From these words, I think it may be useful to the analysis of condensation. I will read this paper tomorrow to confirm my guess.

After two week's exploration, we found that there are a number of existing theoretic results that may be used by our analysis. Except the problem of "wealth distribution", in the treatment of: (1) queuing system, (2) mass transport(including zero range process), there are useful results related to "condensation". This tell us that this series of models are not rare. In contrast, during our discussion, we found that the most difficult point of the problem is to find convincing interpretations of the condensation models and their parameters.

REFERENCES

[1] A. Y. VA Malyshev, "Condensation in large closed jackson networks," *The Annals of Applied Probability*, May 1996.

[2] M. R. Evans, S. N. Majumdar, and R. K. P. Zia, "Factorized steady states in mass transport models on an arbitrary graph," *Journal of Physics A: Mathematical and General*, vol. 39, no. 18, p. 4859, 2006. [Online]. Available: http://stacks.iop.org/0305-4470/39/i=18/a=006

[3] J. D. Noh, G. M. Shim, and H. Lee, "Complete condensation in a zero range process on scale-free networks," *Phys. Rev. Lett.*, vol. 94, no. 19, p. 198701, May 2005.

[4] G. F. Jean-Marc, G. Fayolle, J. marc Lasgouttes, and J. marc Lasgouttes, "Asymptotics and scalings for large closed product-form networks via the central limit theorem," 1996.