Abstract:

A fuzzy programming approach is used in this article for solving the piece selection problem in P2P network with multiple objectives, in which some of the factors are fuzzy in nature. A piece selection problem has been prepared as a fuzzy mixed integer goal programming piece selection problem that includes three primary goals: minimizing the download cost and download time and maximizing speed and useful information transmission subject to realistic constraints regarding peer's demand, peer's capacity, peer's dynamicity, etc. The proposed approach has the ability to handle practical situations in a fuzzy environment and offers a better decision tool for the piece selection decision in a dynamic P2P network. An extensive simulation is carried out to demonstrate the effectiveness of the proposed model. The proposed mechanism has the capability to handle practical situations in a fuzzy environment and offers a better decision tool for the piece selection decision in a decentralized P2P network.

Keywords: P2P network, fuzzy programming, piece selection
1. Introduction:

Peer-to-peer (P2P) network is a decentralized and distributed architecture that divides workloads among the peers in the network. Each peer has equal rights and privileges and equipotent participants in the application. They are supposed to form a peer-to-peer network of nodes. P2P paradigm has established itself to be an effective, scalable and robust networking application to provide services for content sharing and also for personal communications. Unlike traditional client-server model, P2P network combines the resource such as processing power, disk storage or network bandwidth from all peers together and contributes to all peers [1]. Virtual overlay network is formed on top of the physical network topology by P2P network in general. The nodes in the overlay network form a subset of the nodes in the physical topology. Data can be exchanged over the original TCP/IP network, but at the application layer peers can able to exchange data with each other using the logical overlay links. There are several types of P2P applications have been deployed such as file sharing, real-time communications and live media streaming. These applications are uploading and downloading bulk amount of content in a short time span, consuming a major part of the current Internet resources. In General, the P2P content distribution networks can be categorized into four different types based on topology and degree of decentralization. They are decentralized unstructured network, decentralized structured network, partially decentralized network, and centralized network [2].

In a decentralized unstructured network, such as Gnutella and Freenet, all peers act as both server and client equally and the overlay networks are formed by peers. In case of decentralized structured network, like Chord and CAN, each peer in the network performs as both server and client simultaneously, but the overlay network is specifically controlled by a distributed hash table (DHT) [3]. The partially decentralized network has some super-peers that play a more significant role than others peers in the network. FastTrack and Brocade are few of this type. Central server coordinates the interaction between peers in the network in case of the Centralized network, such as Napster and BitTorrent [4]. This system is described by two attributes: centralized index and distributed download. The central server in this network only provides the directory service. The file transfer is performed by distributed peers. In this architecture, resource management is easy and resource discovery are efficient. When any peer requests the central server for certain resources, the server just look up its resource directory and then return the information about resource location immediately to that peer [5].

![Figure 1. P2P network sharing](image)
1.1 P2P network Characteristics

The main goals of P2P network are as follows:

- **Dynamic Environment**: Membership in a P2P architecture is dynamic in nature and peers connect and depart to/from the network at any time without notice. The challenge is to discover a way to arrange these peers so that they can collaborate with each other to provide a useful service.

- **Reliability**: Peers act as both consumer as well as the provider of the resources in the P2P network without restriction. The P2P network is vulnerable to malicious attacks. Some peers may misbehave by flood the network with queries or direct queries to wrong nodes in the network to degrade its performance. A P2P network is not supposed to allow such misbehave peers to degrade the overall performance of the network. It should protect the other peers in the network from these attacks.

- **Scalability and Performance**: Increasing the number of peers in the network will lead to increase the resource’s availability in a P2P network. The resources should be found efficiently and not become increasingly more expensive and complex to locate in terms of bandwidth utilization as the size of the network increases.

Each participating node (peer) in the P2P network performs both a client as well as server functionality. P2P applications construct on this functionality for storage, security, computation, and large scale file distribution. A peer can initiate requests and can respond to requests in the system [6].

The main characteristics of P2P systems are:

- **Sharing**: P2P network allows the sharing of resources and services between peers in the network. Some examples are: content sharing (such as Gnutella [4]), and foraging CPU cycles.

- **Decentralization**: There is no central server in a P2P network, and does not have a single point of failure in the network.

- **Self-Organization**: Each peer takes the responsibility to organize itself based on the information collected from its neighboring peers.

- **Heterogeneous**: Capacities of peers in the P2P network are heterogeneous, since each peer has different capabilities in terms of CPU power, storage space and bandwidth.

- **Churn**: The duration of connection between peers is variable and unpredictable. Each peer may join and leave the network at any time and active for a limited time[7]

1.2. Literature Review

Interest-Intended Piece Selection (IIPS) algorithm has been proposed by Chiang, et al., in order to diminish the last piece problem when a well-built support among the peers maintains [8]. Each IIPS peer favors pieces that has the expected interest in it and will take advantage of the probability of being interesting to its assisting peers when downloaded. The simulation results of IIPS shows that fewer occurrence of piece loss under meticulous conditions and it slightly performs well compared to the rarest-first algorithm of BitTorrent’s in terms of piece diversity [9]. A mathematical model is introduced Liao, et al., which is able of calculating the average delay in downloading file accurately in a heterogeneous BitTorrent-like system. The proposed model is
drawn from least hypothesis, and needs minimal system information. A flexible token-based approach is introduced systems like BitTorrent and applied to trade off among the whole system in order to enhance the performance and fairness in case of excessive bandwidth users, by way of setting its parameters exactly. The proposed mathematical model is extended to calculate the average file download delays in the token-based system. It shows that the application of the model to find the parameter factors which achieves a target performance or fairness.

BitTorrent has been proposed in the year 2011 for improving the downloading time greatly[10]. Since lack of global knowledge and the overlay dynamics during the initial phase is reserved in file sharing or content distribution scenario. This phase causes unnecessary delays in arriving at a stable state and therefore maximizes times to download file which is unclever distribution of piece. A novel class of seed scheduling algorithm introduced is based on a comparative fair system which is implemented using a real file sharing client. Their simulation results show that the proposed file sharing client in BitTorrent improved the average downloading time of a typical file sharing protocol by more than 30%. Guo et al (2011) centered on the effect of introducing BitTorrent nodes in different networks in OPNET [11]. The simulation results also show that the end-to-end delay increases because of the heavy P2P traffic on networks, and the level of congestion is minimized due to the existence of tracker and choke algorithms even network performance is significant. Xia, et al., (2010) did a complete survey on the BitTorrent performance, and reviewed the findings of the different study[12]. Enhancements to BitTorrent’s mechanism were recommended and summarized in the literature survey. Based on these reviews, further enhancement to the BitTorrent performance is recommended.

This article is further presented as follows. Section 2 describes the basic operations in BitTorrent like P2P network and exiting piece selection strategy. Section 3 presents the FMIGP_PSP formulation by considering three important fuzzy goals such as minimizing the download cost, minimizing the download time, and minimizing the redundant transmission. The performance analysis of the proposed technique is described in section 4. Finally, the conclusion is provided regarding effectiveness of the proposed technique in section 5.

2. Basic Operations in BitTorrent like P2P network

In order to contribute in a swarm, a new peer first need to download the metadata file with extension .torrent from an ordinary web server. This peer then communicates the tracker and gets a random list N of other peers of both leechers and seeds that already belong to the swarm. The list N generally has more than 60 randomly selected peers [13]. To avoid unnecessary traffic at the tracker, the peer’s request rate is restricted. The default value in the BitTorrent like P2P network implementation of tracker from Cohen permits a single request every five minutes. Though, in Internet, several implementations of tracker exist and, hence, much smaller time intervals among the requests (e.g., 15 seconds) are likely to be permitted [3, 4]. After getting the list N, the new peer then tries to make bidirectional persistent connections usually TCP links with the peers from it. Those links are resulting successful form the neighbor or peer set. Once the links are created, the peers exchange data among themselves. This initial peer set is increased by directly connected peers to the new peer [8, 9]. At this instant, the new peer knows the neighbors such as remote peers which are interested in it in addition to the neighbors that it is interested in. To get pieces, the new peer needs to be unchoked by neighbors it is interested in first. On the other hand, to send pieces, the new peer needs to unchoke neighbors that are interested in it first. These two procedures are ruled by the peer selection strategy [9,10].
2.1 Piece selection strategy

The widespread acceptance of BitTorrent has driven a lot of techniques to implement it in order to meet the requirements of P2P file download system[11]. Most of these techniques are based on the modification of both the peer and piece selection strategies, respectively. Though, the truth is that the piece selection strategy has received much more attention than the peer selection strategy. Piece selection strategy is very important in BitTorrent network since it affects the performance of the network [12, 13]. To start, it is significant to stress the point that to request data pieces, a local peer needs to be unchoked by a remote peer first. More specifically, remote peer should unchoke the local peer, only then, local peer may request data pieces. The details of piece selection strategy of BitTorrent like P2P network is explained in following Algorithm and comprises of a set of additional specific strategies, which map to three different stages [8, 9]: (i) Random first strategy is used for the initial download which spans for few minutes; (ii) Rarest first strategy is adopted for usual operation; and (iii) End game mode strategy is used for pulling down the last set of remaining pieces, it is more valuable to improve that if at least one block of a piece has been demanded, then the other blocks of this similar piece are demanded with the highest priority. This is called as strict priority strategy and is used throughout the entire piece downloading process, no matter other strategy is also being used concurrently [8, 9].
2.2. Existing Piece Selection Strategies

Piece selection strategy is the procedure of finding which blocks of the file to choose from which peers, by using the knowledge of the file pieces information available in each peers. The piece selection is carried out once a P2P network client creates connections with its active neighboring peers[14]. An inefficient strategy for piece selection could lead to some pieces either becoming poorly replicated. It leads to starvation in some places of the network where new pieces are required [15]. To know how the strategy for selecting pieces in traditional P2P network affects the system, it is essential to study the system wide population of pieces available. This tiny information would help to understand the dynamics and evolution of the traditional P2P network’s swarming technique, and particularly the effectiveness of the strategy used by traditional P2P network to ensure an even distribution of pieces [16].

2.2.1. Priority based Piece Selection strategy (PPS):
According to this strategy, the pieces of the file are downloaded in the exact order they need to be played back, starting from the first piece of the original file. In a priority based selection, when a single piece has been required, the remaining pieces are demanded from the particular piece before getting pieces from any other peers. This provides assurance that downloading the entire content complete as soon as possible [17].

2.2.2. Local Rarest First Piece Selection strategy (LRF):

It is a default piece selection strategy in most of the P2P network model in which the local peer maintains the record of the owner’s count of each file piece in its peer set. It requires to download the rare piece among the neighbors as first in view of keeping the file segments available at all the time. BitTorrent P2P model allows every peer to share their rare pieces first in order to enhance the overall system throughput [18]. Most of the P2P systems employ rarest first algorithm with some minor modification due to its distribution efficiency. The rarest first algorithm is preferred for three reasons. First, it increases the probability of usefulness of a BitTorrent node to its peers. Next, it distributes the file pieces equally in the view of reducing the risk during file download
period. Lastly, the algorithm prompts the BitTorrent peers in downloading different variety of pieces from the seed which facilitates in improving the rate at which new pieces are placed into the group.

2.2.3. Random Piece Selection strategy (RPS):
It is popularly known piece selection approach where the local peer always picks the randomly accessible piece from the remote peers till an entire file is assembled, when the peer connects a torrent initially. BitTorrent utilizes this strategy strictly for first few pieces in order to speedily fill up the initial file contents and then changes to the rarest first strategy to guarantee to download its first few pieces quickly than the rarest first strategy to acquire entire piece as fast as possible, which is necessary as some pieces are need to give in return with TFT Choke algorithm [19]. Even though it is utilized in only during the initial phase to quickly obtain a piece for sharing, it is considered as one of the important and popularly used selection mechanism as it does not need additional information such as sorted list as required by LRF.

2.2.4. Bandwidth Based Piece Selection strategy (BPS):
In BPS, peers are categorized into two such as high bandwidth peers and low bandwidth peers. The average delay of downloading pieces from both the group is calculated. To analyze the performance of the high bandwidth peers and low bandwidth peers, a token system is commenced. The primary use of tokens is to exchange blocks between the peers [20,21]. To assist trading among peers, token tables are created and maintained by them, which contain the information about the tokens of peer. When the peer uploads $U_u$ bytes to a neighbor peer, the neighbor peer’s token reduced by $T_d U_u$. On the other hand, neighbor’s value of token increases by a factor of $T_u U_d$ when a peer download $U_d$ bytes by the peer from their neighbor. The above method ensures fairness among all the nodes actively participating in the network.

2.2.5. Proposed Piece Selection strategy – Fuzzy adopted Piece Selection Strategy (FPS)
The major objective of this article is to investigate the impact of BitTorrent’s mechanisms and parameters on overall performance. The very important key factor lies in knowing whether BitTorrent can retain all system uplinks active and use it completely. It means that optimal download time and also optimal load on the origin server. There are several reasons for using less uplink capacity. One major reason is that nodes take independent downloading decisions with respect to file blocks. Therefore, neighbors might receive a similar set of blocks reducing and degrading their utility. How the blocks become replicated is governed by using the piece selection strategy of peers. It is noted that the LRF is default policy used by BitTorrent, may not function well in all scenarios [22,23]. It is a key factor to find out if other policies for choosing pieces work equally well and under what workloads strategy choice becomes vital. Other strategies also limit peer connections resulting in a situation where a node decides not to assist its peer even though having useful blocks to provide. Also important BitTorrent mechanisms are dependent on factors like number of peers which interacts with each peer and maximum allowed uploads [24]. These mechanisms relate differently and performance could be affected by specific parameter settings. In such decision making situations, high degree of fuzziness and uncertainties are involved in the data set [25]. Fuzzy set theory provides a framework for handling the uncertainties of this type. The proposed model for piece selection is integrated a novel fuzzy solution approach which gives an opportunity to the peer to obtain preferred achievement levels to download the entire content. In this article, the BitTorrent like network is simulated for assessing the effect of core mechanisms on the system under different piece selection strategies and different workloads. The existing piece selection mechanisms are compared with the proposed fuzzy approach to verify the fairness factor
by means of utilizing mean upload utilization and mean download utilization under a network of nodes [26]. Detail steps and theoretical background of the proposed mechanism is explained detail in the further sections.

3. Brief about Fuzzy logic and Fuzzy goal programming:

Fuzzy logic is the important component of fuzzy set theory. It deals with the knowledge representation and inference from knowledge. It deals with uncertain knowledge and developed based on mathematical principles and degree of membership. There is no ambiguity in classical sets and therefore they have crispy margins. But in fuzzy set, certain levels of uncertainty are permitted and therefore the regions may be defined ambiguously. Hence it is concluded that the fuzzy logic has the ability to efficiently incorporate the mechanism for reasoning that are approximate rather than exact information. Boolean logic is double valued (0 or 1) but fuzzy logic takes the range of values between 0 and 1. Linguistic variables are basic building blocks of fuzzy logic. They represent the ambiguity existing in the system and may be defined as variables whose values are represented as terms or sentences. Unions, conjunction and implication are various logical operations on fuzzy logic. Unions of sets are represented by ‘OR’, conjunctions are denoted by ‘AND’ and implications are represented by ‘IF.. THEN’. Assume 2 fuzzy sets F1 and F2 defined in space S, the union of the two sets are denoted by set F3 where F3 belongs to S, then the respective membership function is defined as:

\[ \mu_{F3}(M) = \max[\mu_{F1}(M), \mu_{F2}(M)] \]  

(1)

where \( \mu_{F1}(M) \) and \( \mu_{F2}(M) \) are the membership function of set F1 and F2 respectively.

For the conjunction operations of sets F1 and F2, the respective membership function is defined as

\[ \mu_{F3}(M) = \min[\mu_{F1}(M), \mu_{F2}(M)] \]  

(2)

For Implication operations the respective membership function is described as

\[ \mu_{F1\rightarrow F2}(M,N) = \mu_{F2}(M,N) = \min[\mu_{F1}(M), \mu_{F2}(M)] \]  

(3)

The main steps in fuzzy algorithms are Description of input / output fuzzy variables, Fuzzification process, Inference, Specification of rules and process of Defuzzification. Either a system variable or linguistic variable are the input / output fuzzy variable. In the diagram the variables small, average, large are called as the linguistic variables which represents the imprecision value of existing in the system. Crisp inputs are mapped to crisp outputs in Fuzzy logic system. The vital part of fuzzy logic is fuzzy inference system (FIS) which is used to map a nonlinear input data into a scalar output using set of fuzzy rules and is responsible for approximate the reasoning and inferring control actions. The process of mapping consists of input/output membership functions, fuzzy logic operators, set of fuzzy if–then rule base, aggregation of output sets, and process of defuzzification. A common model of a fuzzy inference system (FIS) contains four subsystems that are the fuzzifier, inference engine, rule base, and defuzzifier. The rule base consists of linguistic rules which are designed by experts [27, 28]. The rules can also be derived from numeric data. Once the rules have been formed, the FIS can be planned as a system that correlates an input vector to an output vector. Real world input variables are mapped into corresponding fuzzy sets by finding out the degree to which they belong to each of the fuzzy sets using membership functions in fuzzifier. The consequence of the fuzzification is a fuzzified data which describes the level of fact of each of these linguistic variables. The inference engine is used to map input fuzzy sets into output fuzzy sets. It involves determination of the level to which the predecessor is fulfilled for each rule. One or more rules may be activated at the same time. During the process of aggregation
all the rules are merged into a single fuzzy set. Defuzzification is the final step which translates output fuzzy sets to again a crisp number [29].

![Fuzzy logic system](image)

**Figure 4. Fuzzy logic**

4. Multi objective piece Selection model

Multi-objective optimization problem can be described as follows

\[ M_l = \min M_l(V) \text{ for all } l \]

\[ s.t \]

\[ (Av)_j \leq b_j \text{ for all } j \]

\[ x \geq 0 \]

where functions \( M_l \) are the objectives and \( v \) is the vector of variables. A solution \( v^* \) is efficient and feasible if and only if for all other feasible solutions \( v \), \( M_l(V^*) \leq M_l(V) \) with at least one strict inequality.

There are five main methods are used in most of the multi objective problems such as (a) hierarchical based method (b) utility based method (c) goal programming method, (d) pareto method (e) interactive method [30]. Each method has its own pros and cons as explained in the general literature on multi objective optimization problems.

4.1. linear model for piece selection problems

A typical linear model for piece selection problems as follows

Index set

\[ j \text{ index for peers, for all } j=1,2,\ldots,m \]

Decision variable

\[ p_j \text{ the number of pieces downloaded from } j^{th} \text{ peer} \]

parameters

\[ A \text{ aggregate demand of the pieces over a fixed download plan period} \]

\[ m \text{ number of peers ready to upload the pieces} \]

\[ D_j \text{ download cost and time needed to obtain pieces from peer } j \]

\[ C_j \text{ percentage of the useful information transmission no of pieces delivered by peer } j \]

\[ O_j \text{ the speed at which pieces are download from peer } j \]

\[ B_j \text{ bandwidth of the jth peer} \]

The multi objective programming problem formulation for piece selection is as follows

\[ \text{Minimize } z_1 = \sum_{j=1}^{m} D_j(x_j) \]
Maximize $z_2 = \sum_{j=1}^{m} C_j(x_j)$ \hspace{1cm} (5)

Maximize $z_3 = \sum_{j=1}^{m} O_j(x_j)$ \hspace{1cm} (6)

such that

$$\sum_{j=1}^{m} x_j = A$$ \hspace{1cm} (7)

$x_j \leq B_j$

$x_j \geq 0$ and integer

Objective function (1) minimizes download cost and time needed to obtain pieces from peer $j$. Objective function (2) maximizes percentage of the useful information transmission no of pieces delivered by peer $j$. Objective function (3) maximizes the speed at which pieces are download from peer $j$. Constraint (4) ensures that the aggregate demand of the pieces over a fixed download plan period is equal or less than its capability. Constraint (5) ensure there is no negative orders. In this problem target level of objectives and demand assumed to be fuzzy.

4.2. Fuzzy model for piece selection problem

Introductory definitions

Consider the fuzzy multi objective programming problem (7) with $n$ objective functions and $k$ fuzzy constraints:

Find $y$

Such that

Approximately $C_l \geq Z_l$, $l \in J_1$ \hspace{1cm} (8)

Approximately $C_l \leq Z_l$, $l \in J_2$ \hspace{1cm} (9)

Approximately $d_t = e_t$, $t \in V$

$y \in Y$

where

$J_1 \cup J_2 = \{1, \ldots, n\}$, $J_1 \cap J_2 = \emptyset$ and $Y$ is a set of deterministic linear constraint and sign boundaries.

$$C_l Y = \sum_{j=1}^{m} C_{lj} y_j \hspace{1cm} l = 1, \ldots, n$$ \hspace{1cm} (10)

$$d_t Y = \sum_{j=1}^{m} d_{jt} C_{lj} y_j t \hspace{1cm} t = 1, \ldots, n$$ \hspace{1cm} (11)

for $l \in J_{1,2}$, $Z_l$ is the inexact aspiration level for the $l^{th}$ objective function.

$Z_l \in [Z_{l}^{LB}, Z_{l}^{UB}]$ represent the inexact lower and upper bounds respectively for the $l^{th}$ fuzzy objective function.

$e_t \in [e_t^{LB}, e_t^{UB}]$ represent the inexact lower and upper bounds respectively for $l^{th}$ fuzzy constraint.

According to fuzzy mathematical programming, each fuzzy objective are defined in terms of fuzzy subsets with the appropriate membership functions denoted by $\mu_l(C_Y)$ for $l \in J_{1,2}$ and $\mu_l(d_Y)$ for
t \in V$, respectively. Assuming that membership functions are linear, mathematical definitions are described as follows

$$\mu_i(C_iY) = \begin{cases} 
1 & \text{if } C_iY \geq Z_i^{UB} \\
(C_iY - Z_i^{LB})/Z_i^{UB} - Z_i^{LB} & \text{if } Z_i^{LB} \leq C_iY \leq Z_i^{UB}, \text{ for all } 1 \in J_i \\
0 & \text{if } C_iY \leq Z_i^{LB} 
\end{cases} \quad (12)$$

$$\mu_i(C_iY) = \begin{cases} 
1 & \text{if } C_iY \leq Z_i^{UB} \\
(Z_i^{UB} - (C_iY))/(Z_i^{UB} - Z_i^{LB}) & \text{if } Z_i^{LB} \leq C_iY \leq Z_i^{UB}, \text{ for all } 1 \in J_2 \\
0 & \text{if } C_iY \geq Z_i^{LB} 
\end{cases} \quad (13)$$

$$\mu_i(d_iY) = \begin{cases} 
0 & \text{if } d_iY \leq e_i^{LB} \\
(d_iY - e_i^{UB})/(d_i^{UB} - d_i^{LB}) & \text{if } e_i^{LB} \leq d_iY \leq e_i^{UB} \\
(e_i^{UB} - d_iY)/(d_i^{UB} - d_i^{LB}) & \text{if } e_i \leq d_iY \leq e_i^{UB} \\
0 & \text{if } d_iY \geq e_i^{UB} 
\end{cases} \quad (14)$$

$\mu_i(C_iY)$ in eq 1 represents linear monotone increasing membership function for maximization type objective with fuzzy aspiration levels. $\mu_i(C_iY)$ in eq 2 represents minimization type objective with fuzzy aspiration levels and eq 3 is a triangular membership function $\mu_i(d_iY)$ for constraints.

4.3 Fuzzy additive model

Fuzzy additive model based on Tiwari et al study for the multi objective programming model is given in the following equation [31]. Variables donated by $\lambda_i$ and $\lambda_j$ represents achievement levels of fuzzy objective functions and fuzzy constraints respectively.

$$\text{Max} \left( \sum_{l=1}^{n} \lambda_i + \sum_{t=1}^{k} \lambda_j \right)(n+k) \quad (15)$$

Such that

$\lambda_i \leq \mu_i(C_iY), l \in J_1 \cup J_2$

$\lambda_j \leq \mu_i(d_jY), t \in V$

$\lambda_i, \lambda_j \in [0,1], l = 1, ..., n; t = 1, ..., k$

$y \in Y$
4.4 Augmented max-min model

Augmented max-min model based on Lai and Hwang's approach [32] for model is described as follows:

$$\max \lambda + \frac{\sum_{i=1}^{n} \mu_i(C_iY) + \sum_{i=1}^{k} \mu_i(d_iY)}{(n + k)}$$

such that

$$\lambda \leq \mu_i(C_iY), l = 1,2,...,n$$
$$\lambda \leq \mu_i(d_iY), t = 1,2,...,n$$
$$y \in Y$$
$$\lambda \in [0,1]$$

$\lambda$ is the minimum satisfaction degree and described as follows,

$$\min_{i,l} \{\mu_i(C_iY), \mu_i(d_iY)\}, \text{for } l = 1,2...n; t = 1,2,...,k$$

4.5 The proposed fuzzy model

$\lambda$ is the minimum satisfaction degree defined in eq

$$\max \lambda + \frac{\sum_{i=1}^{n} \mu_i(C_iY) + \sum_{i=1}^{k} \mu_i(d_iY)}{(n + k)}$$

such that

$$\lambda \leq \mu_i(C_iY), l = 1,2,...,n$$
$$\lambda \leq \mu_i(d_iY), t = 1,2,...,n$$
$$\mu_i(C_iY) \geq \sigma_i, l = 1,...,n$$
$$\mu_i(d_iY) \geq \sigma_i, t = 1,...,k$$
$$y \in Y$$
$$\alpha_i, \alpha_i, \lambda \in [0,1]$$

Parameters $\alpha_i$ and $\alpha_i$ represents the minimum acceptable achievement levels for the $l$th constraint respectively determined by the decision making peers.

4.6. Fuzzy goal programming approach:

Let $D_i$ and $H_i$ be the desired level of achievement and highest level of achievement for the $i$th objective function respectively. To solve piece selection problem based on the fuzzy goal programming approach, the following general steps are carried out:

1. Solve the multi objective piece selection problem as a single objective piece selection problem, by considering only one objective as objective function and ignoring all other objectives.
2. Find the value of each objective function at each solution obtained in the previous step.
3. from step 2, compute each objective best ($D_i$) and the worst ($H_i$) values corresponding to the set of possible solutions.
4. Describe a membership function $\mu_i$ (linear $\mu_i^D$, hyperbolic $\mu_i^H$ or exponential $\mu_i^E$) for the $i$th objective function respectively. There are three possible membership functions can be used such as linear, exponential and hyperbolic membership function. It is stated in the next section.
5. Resolve the corresponding crisp model attained in step 4.
The solution obtained after the successful execution of step 5, will be the feasible and compromise solution of MOPP model.

**5. Result and discussion**
Extensive Simulations were performed after changing configuration of the OCTOSIM simulator. Simulations were performed with 100,200,300 and 600 nodes in the network. The following metrics are used to evaluate the performance of the proposed method in the simulations: download cost, download time and packet redundancy or useful information transmission subject to realistic constraints regarding peer's demand, peer's capacity, peer's dynamicity.
1. Download cost – This metric refers to the effort of the client need to spend in the system to download the needed data.
2. Download time – This metric refers to the time needed to the client for downloading the content.
3. Packet redundancy - This metric is referred to transmit and obtain useful information to and from other peers in the network.
4. Failure rate: It is defined as the number of peers are not able to complete the downloading of content due to missing of some blocks.

At the time of simulation, most of the links are assumed to be an ADSL by keeping more download bandwidth than upload bandwidth. The simulation parameters are given in Table 1, and the utilization of uplink and downlink bandwidth is shown in Table 2.

| Parameter            | Value |
|----------------------|-------|
| Connection           | ADSL  |
| Bandwidth availability | 2 mbps |
| File size  | 1 Gb                           |
|------------|--------------------------------|
| Block size | 1 Mb                           |
| Neighbor node count | 10                        |
| Number of Node   | 100 to 600 nodes               |

Table 1. Simulation settings

| Download Bandwidth (Kbps) | Upload Bandwidth (Kbps) | Number of nodes active (Kbps) |
|---------------------------|-------------------------|-------------------------------|
| 128                       | 128                     | 50                            |
| 256                       | 256                     | 50                            |
| 384                       | 256                     | 50                            |
| 512                       | 256                     | 50                            |
| 640                       | 256                     | 50                            |
| 1280                      | 256                     | 50                            |

Table 2. Availability of Bandwidth in each node

The number of active nodes in the network is increased from 100 to 600 gradually. The graph in figure 6 shows the performance of the proposed system with the linearly increasing number of nodes in the network. The proposed method reduces the amount redundant data flow even when number of peer increase in the network. The graph in figure 7 depicts the performance analysis of proposed system with existing systems by measuring the download time of the requested content. Download time is measured in terms of ms. Download time is low when system use the proposed system. It is increased when number of peers increased in the network because of searching time. The graph in figure 8 depicts the performance analysis of proposed system with existing systems by measuring the download cost of the requested content. Download cost is the measure of effort needed to download the content. It is minimized with proposed system. The graph in figure 8 depicts the performance measure of proposed system with existing one by measuring the failure rate. It shows that the proposed system outperforms the existing system even when some peers leaving the network.

![Figure 6. Performance measure on Traffic Redundancy](image)
Figure 7. Performance measure on Download Time

Figure 8. Performance measure on Download Cost
6. Conclusion

It is known that obtaining optimal solution for single objective problems can be different to those problems consisting of multi objectives. In fact, the decision maker needs to minimize the total drift time. Each of these objectives is effective from a common point of view. Since these objectives conflict with each other, a solution may perform well for one objective or it gives inferior results for others. For this reason, piece selection problems have a multi-objective nature. In this article, piece selection problem is treated as a multi objective linear programming problem. The literature surveyed for the studies which handle piece selection problem by fuzzy multi objective mathematical programming and they are examined related to their solution approaches. A typical multi objective piece selection model which considers three objective functions as minimizing the download cost and download time and maximizing speed and useful information transmission with fuzzy desire levels respectively and fuzzy demand is used to make fuzzy mathematical models. Each fuzzy factor is characterized mathematically by using a suitable linear membership function. Both fuzzy additive and augmented max–min models provide nondominated solutions. Augmented max–min model solution is stable additionally. The proposed model is exactly same as the augmented max–min model apart from the additional limitations related with the decision making peers preferred achievement levels. Hence, both the proposed model and the solution approach provide an opportunity to the decision making peers to obtain its own preferred achievement levels for the objectives and for the demand level in a non-dominated solution case. Trapezoidal memberships for demand, nonlinear memberships for download time, and cost and fuzziness in each peer’s capacity may be considered.

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