行政院國家科學委員會專題研究計畫 成果報告

分散式網路信譽系統 ：基礎、應用、經濟分析
研究成果報告(精簡版)

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報告內容

一、前言

由於網際網路的成熟發展，各式於網際間運作如商務往來、資訊傳播與存取、人際溝通等資訊應用也蓬勃發展。個人或組織藉由全球資訊網取得所需資源與服務的需求也日漸激增。於線上交易環境建立與維護消費者信任關係之重要性已被廣泛認同，在缺乏直接的信任關係下，消費者傾向在正式與服務提供者進行互動前先觀察他人過去與供方的互動經驗，進而採取行動。許多電子商務的運作，藉由推薦與評價機制的運作，來獲得產品本身或服務提供者的信譽評等。服務請求者可藉由此評價資訊作爲決策指標。使用者若能因獲得符合需求的推薦而提高購買動機與意願，甚至是安全性與信心的滿足，這將大幅提升網際商務活動本質上缺乏的正向因子，進而促進整體商務活動的活絡與發展。

爲此，本專題研究告包含一個以網路信譽技術爲基礎的服務推薦系統。各形式的服務內容如檔案、資訊、同好社群、專家諮詢等，皆可藉由此系統的推薦機制取得可靠的服務來源。服務推薦系統包含了三個最主要的核心流程：1.信譽評等的聚合(aggregation)－針對系統的回饋機制、介面，以及如何將回饋結果聚合成信譽評等進行探討；2.推薦之運算：如何進行信任網路推論，以及使用模糊推論(fuzzy inference)的方式將信任值與信譽評等進行推論、運算成爲單一有序的個人化推薦結果；3.信任網路之調整：如何用模糊推論進行信任網路之調整，使得有效的推薦結果擴展、調整原有的信任網路。此外，兩項今熱門的網路社群工具如即時通訊 (instant massaging)及部落格(blog)也將於報告中呈現如何與信譽技術進行整合，以顯示網路信譽技術對於時下熱門的社群工具之影響與關鍵性。

二、研究目的

信任的建立能減少網際交易時的障礙，許多研究顯示「信任」於網際商務活動中有顯著的重要性[24,23,8,7]，並且關鍵影響網際商務運作的成功與否 [24]。現今諸多的商務運作藉由「線上信譽系統」 (online reputation system) [25]之運作協助信任關係之建立並促進交易行爲。這些機制的廣泛運用，已經影響使用者的習慣，儼然形成各式服務的重要推薦來源。然而，在網際網路的互動中，由於不同地域、文化、年齡、種族等所造成的主觀偏好與特性，使得眾多推薦來源的複雜度與差異性大幅提升。

因此，本研究以社會網路(social network)的人際關係，建立以信任機制爲基礎的 peer-to-peer 服務推薦系統。我們使用了社會網路信任機制及人工智慧方法來解決「信任度」與「信譽評等」等包含不確定性的決策因子呈現與推論。同時，系統以多準則決策的方法論提供「適性化、直覺」的個人推薦。此外，與他人的信任關係會根據推薦的正確性進行適性改變，而社會網路範圍也會因此建立、延展。在兩個關鍵應用整合上，trust-based 之社會網路即時通訊系統透過信任機制的使用，每個人不但可以透過朋友或朋友的朋友之間的信任來篩選在網路上傳播的訊息，所有在這個信任爲基礎社會網路的成員，還同時互相地幫對方選擇有用的訊息，將訊息傳播到每一個需要的人。在部落格

網誌的整合應用上，藉由大眾的實體經驗以及人脈的拓展，每個人都可以利用彼此信任的關係互相幫助，透過信任網路關係找到自己有興趣的網誌文章，更加強以及延展網誌的社會網路。

三、文獻探討

本節將針對系統最主要組成因素－「信譽、信任網路、模糊邏輯、評價與回饋機制」的相關理論、研究以及「即時通訊與部落格」之應用現況進行探討。

3.1 信譽

「信譽」(reputation)乃對於一個人或事之聲譽或名望的普遍看法[2]，使用者藉由回饋介面，提供個人對於產品本身或服務提供者的互動及使用之經驗、評價，信譽系統再將這些經驗回饋進行彙整，形成服務及其提供者的信譽評等，作爲服務的推薦來源以協助服務請求者做出適當決策。

信譽系統的使用尤其對於相對「高風險」及「高價」的產品交易時有較顯著的影響[4]，然而 Resnick et al.[26]的研究顯示，其明確的效用並無明確結論。另外，在 eBay 的評價系統中高達 99%的正面評價[27]顯示其評價結果的正確性與可靠性值得商榷。因此，許多信任網路的研究與應用，試圖將資訊來源進行過濾，提供更可靠、個人化的推薦結果。

3.2 信任網路與推薦

信任(trust)具有推論(inference)與傳佈(propagation)之特性，信任網路即藉由這樣的特性推論而成。信任網路為線上的社會網路(online social network)，代理人於此網路上建立起信任關係的連結，此信任關係用於評估代理人的看法與信念之「品質」 [17]。現今有許多的研究利用信任網路的運作進行不同的服務推薦，Golbeck and Hendler [14,13]藉由信任網路進行電影推薦社群，以及電子郵件過濾；Singh et al. [20,3]藉由社交指標(sociality)與專業能力(expertise)的結合，推探出服務提供者；Ding et al. [16]藉由推薦信任(referral trust)與專業領域信任(domain trust)進行知識委外(knowledge outsourcing)，並認為信任網路的使用可明顯促進知識委外之效能。

3.3 模糊邏輯

信任與滿意評價都是對於事或物的看法與主觀評價，人們經常以相當含糊(vague)的方式來描述[11]。而模糊邏輯(fuzzy logic)能有效處理不精確(imprecise)及不明確(uncertain)的資訊[30]，因此，本系統藉由模糊邏輯的使用，使得使用者可以語言詞彙(linguistic term)描述「滿意度、信任度」。語言詞彙可代表的一範圍之值，對於使用者而言比起用常見的「單一値」較容易且適合表示上述兩者。

3.4 評價與回饋機制

由於滿意評價累積而成的信譽是進行推薦時最主要的資訊來源，因此回饋機制能否忠實反應互動時的滿意水準，對於推薦系統的準確性有密切之影響。

Griffiths et al.[21], Xiong and Liu [18],以互動的成功「次數」或與失敗的比例結果作爲服務提供者的信譽；Sabater and Sierra [15] , Sen and Sajja [29]分別以[-1,1],[0,1]實數範圍表示；eBay[9]以「明確」的三個等級－好(1)，差(-1)，中等(0) 進行滿意評價，Amazon[1], OnSale Exchange[22], Epinions[10] 等線上商務、拍賣網站也採取類似作法。以上常見回饋機制，主要有下列特性：[21][18]單純地用「成功」或「失敗」的二分法進行兩極化

的評價，難以忠實反應服務的滿意程度；[15][29]實數範圍的表示方式對於進行評價的使用者而言，難以確切的藉由數字來表示自己的滿意度；[9][1][22][10]以語言詞彙表示程度，但在進行信譽的平均值處理時，仍對應至明確的整數進行計算；[21][18][29][9][1][22][10]皆無提供多面向的評價。當我們評估服務水準時，通常需要藉由更多的面向(dimension)來衡量整體的滿意水準。

3.5 部落格

部落格以極快的速度在成長，並改變了以往傳播資訊的方式成爲新一代的網路溝通方式。一般的部落格提供了好友名單(friend list)加強及延展部落格的連結性服務，雖然這種連結方式非常的簡便，但是使用者將被迫面對他不熟悉的朋友名單，所以使用者通常不是花費大量的時間去做瀏覽的賭注就是害怕或者不願意浪費太多的時間去做類似的瀏覽。我們希望這個問題可以被改善，在這個社會網路中加上信任的機制增強網誌的連結性與社會機能。

3.6 即時通訊

在傳統的即時通訊系統，有兩個很大的缺點，第一，連結的方式僅僅限於一個階層之間，當節點的距離大於 1 的時候，訊息就被迫中斷；第二，沒有一個有效的訊息阻擋機制，根據這兩方面，我們希望利用信任機制可以建立起一個有別於傳統的聯絡人清單的聯絡人網路。聯絡人從自己的朋友這個範圍，增加到朋友以及朋友的聯絡人清單。因此，我們在聯絡人的網路中，增加信任的機制，讓使用者互相給予信任值的評分，在我們通訊系統中將利用這些使用者自己判斷的信任值，作爲是否傳播訊息的依據。

四、研究方法與流程

在本研究中，採用了模糊邏輯(fuzzy logic) 進行信任與服務滿意度的表示，同時用於推薦值之模糊推論。我們也參考了典型信任網路推論方法及圖形(Graph)來進行信任值的推論，並運用多準則決策制定(Multi-criteria decision making)方法論中的 TOPSIS（Technique for Order Performance by Similarity to Ideal Solution）評估法協助個人化的推薦資訊的取得。以下將系統最主要流成區分爲三(圖 1)大步驟，並將上述各方法論之整合方式詳述於下。

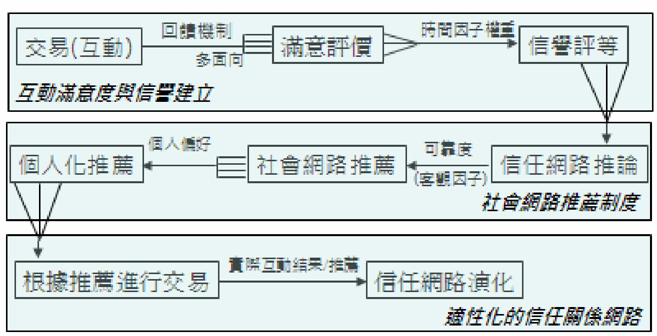


圖 1 系統流程

4.1 網路信譽系統

4.1.1 互動滿意度與信譽建立

由於滿意評價累積而成的信譽是進行推薦時最主要的資訊來源，因此回饋機制能否

忠實反應互動時的滿意水準，影響著推薦系統的準確性。在本研究中，為使不同面向的滿意經驗充分匯集，提供更適性化的決策支援，我們以「品質、及時性、成本」三個重要面向作為衡量滿意度的指標- q, t, c。$Sr_{\beta}^{d}(k)$ 表使用者與 β 在第 k 次的互動中，對於面向 d 的滿意評價，而此滿意評價以五個使用者容易明瞭的語言詞彙－「極差（EB）、差（B）、尚可（N）、佳（G）、極佳（EG）」表示程度(表 1)，並以「梯形模糊集（trapezoid fuzzy set）」表示其對應的模糊集 (圖 2)。

Linguistic terms	Trapezoid fuzzy numbers $\tilde{s}_n$
極差*(EB)*	(0,0,0.1,0.2)
差*(L)*	(0.1,0.2,0.3,0.4)
尚可*(N)*	(0.3,0.4,0.6,0.7)
佳*(G)*	(0.6,0.7,0.8,0.9)
極佳*(EG)*	(0.8,0.9,1,1)

表 1 滿意度 Linguistic terms 與 fuzzy numbers

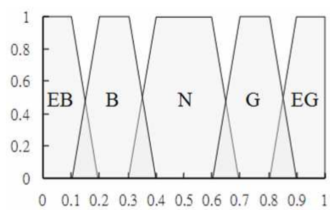


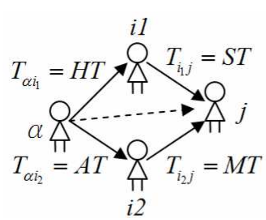
圖 2 Satisfaction Fuzzy Set

所有互動所累積的滿意評價即為信譽評等。在決策支援的過程中，越接近當前時間的經驗資訊較能確切的反應事實，因此，我們賦予每次互動所產生的滿意評價一權重因子 *fw*，代表該次互動經驗的新鮮度：$fw(j) = fresh(j) \Big/ \sum_{j \in k} fresh(j)$

其中 $fresh(j) = time(j)/time(current)$，趨近 1 表示越接近當前時間。所以，使用者過去與 β 互動中在面向 d 整體的信譽評等為：$Rp_{\beta}^{d} = \sum_{j \in k} fw(j) \times Sr_{\beta}^{d}(j)$

4.1.2 信任網路推薦制度

經由信任網路關係推論所得的推薦值受信任度的影響，這種信任關係的推論我們採取與[8]相同的圖形推論觀念取得。在信任度上以語言用辭定義出「完全不信任（*AD*）、高度不信任（*HD*）、普通不信任（*MD*）、微不信任（*SD*）、中等（*NT*）、微信任（*ST*）、普通信任（*MT*）、高度信任（*HT*）、完全信任（*AD*）」作為信任度的衡量範圍，對應的模糊集如圖(4)。假設一簡易信任網路如圖(3)所示，



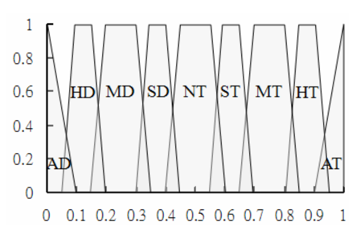


圖 3 信任網路推論　　　　　　　　　　圖 4 Trust fuzzy set

α 之朋友清單中有 $N=\{i_1,i_2,..,i_n\}$ 個人，α 與這 n 個人有「直接」信任關係 T（以實線表示），如 α 欲推算與 j 的「間接」信任關係(以虛線表示)，且朋友中的 i_1,i_2 與 j 有直接信任關係，則以公式：$T_{\alpha j}=\sum_{i\in N}T_{\alpha i}.T_{ij}\Big/\sum_{i\in N}T_{\alpha i}$ 進行推論。進行此推論前必須將個別 T 值以 centre of gravity[19]的方式進行反模糊(defuzzification)取得單一值(crisp value)，再套用上述推論公式取得間接信任值：$T_{\alpha j}=0.875\times0.625+0.9707\times0.75/0.875+0.9707=0.6907$

令推薦來源集合爲 S，則 S 包含了集合 f-代表朋友及社會網路推論關係，集合 st-代表陌生人：$S= f + st$, and $\forall i\in st, i\notin f$ 。來自集合 f 的推薦爲：$Rc_{i\beta}^{d}=F\left(T_{\alpha i},Rp_{i\beta}^{d}\right)$，其中 $i\in f$ ，$T_{\alpha i}$ 爲服務請求者 α 對推薦者 i 的信任度。推薦值 Rc 即藉由信任度 T 與信譽評等 Rp 進行模糊推論所得，其模糊集之定義與 Sr 相同，表(2)所示爲部份推論規則子集。

1. if *T* is *AT* and *Rp* is *EG* then *Rc* is *EG*.
2. if *T* is *HT* and *Rp* is *EG* then *Rc* is *EG* or *very G*.
3. if *T* is *MT* and *Rp* is *EG* then *Rc* is *a little EG* or *very G*.
4. if *T* is *ST* and *Rp* is *EG* then *Rc* is *very G*.
5. if *T* is *NT* and *Rp* is *EG* then *Rc* is *very N or G*.
6. if *T* is *HT* and *Rp* is *EG* then *Rc* is *EG* or *very G*.

表 2 推薦值模糊推論規則子集

在陌生人集合 st 的推薦上，由於過去未曾與其接觸，無法經由社會網路中推論而取得其信任值，因此在整體推薦的計算上會經由權重 γ 的分配而與集合 f 有所差異。此外，我們採用[2]的概念另外納入兩因子：Fc 與 Fd ，作爲可靠度 Rl 之客觀衡量因子，其分別代表「親密因子」（closeness factor）與「穩定因子」（stable factor）。「親密因子」爲社群觀點上的「親近程度」，亦即互動的頻繁度，下爲基本運算方式：

$$Fc_{\beta}^{i}=\begin{cases}\sin\left(\dfrac{\pi}{2l}k\right) & \text{, if } k<l\\ 1 & \text{, otherwise}\end{cases}$$

「穩定因子」表示的是推薦者過去與候選者每次的互動評價之變動性，如果互動的滿意評價普遍上差異不大則稱之爲穩定，變動性高則不穩定，計算方式如下：

$$Fs_{\beta}^{i}=1-\sum_{j\in k}fw(j).\left|Is_{i\beta}^{d}\left(j\right)-E_{i\beta}^{d}\right|$$

可靠度 Rl 即爲兩因子加權後之總和：$Rl=wr\cdot Fc+(1-wr)\cdot Fs$, $Rl\in\left[0,2\right]$ 。其使用並不限於受信任的推薦群中，此因子可同時作爲陌生推薦群的可靠性衡量。因此，完整的推薦度如下：$Rc_{\beta}^{d}=\left[\gamma\left(\sum_{i\in f}F\left(T_{\alpha i},Rp_{i\beta}^{d}\right)\cdot Rl_{i\beta}\right)\Big/\sum_{i\in f}Rp_{i\beta}\right]+\left(1-\gamma\right)\left(\sum_{i\in st}Rp_{i\beta}^{d}\cdot Rl_{i\beta}\right)\Big/\sum_{i\in st}Rl_{i\beta}$

在取得多方推薦後必須根據制定的條件從眾多候選者中選擇最符合其需求的服務提供者，本研究採取 *TOPSIS*[6]方法進行決策的制定。在使用 TOPSIS 進行決策制定時，系統會先將 Rc_β^d 進行反模糊(defuzzify)成爲單一值，因此正、負理想方案－ Rc_+^d, Rc_-^d 分別爲 1,0。假設服務請求者對於此次服務各面向的權重定義爲：*Wq*=0.5, *Wt*=0.3, *Wc*=0.2，在取得所有的推薦後建立起「推薦決策矩陣」如表(3)，並進行以下運算：

1. 將各面向推薦值及正負理想方案進行權重分配，產生如表(4)的「權重化推薦決策矩陣」。
2. 計算各推薦方案於各面向距正、負理想方案之距離－運算式如下，結果如表(5)：

$$S_m^{\ +} = \sqrt{\sum_{n\in d}\left(Rc_m^n - Rc_+^n\right)^2},\ S_m^{\ -} = \sqrt{\sum_{n\in d}\left(Rc_m^n - Rc_-^n\right)^2}\ ,\ \text{where } m \in \beta$$

3. 計算各推薦方案對理想方案之相對接近程度，運算式如下，結果如表(6)：

$$C_m^{\ *} = S_m^{\ -} \big/ S_m^{\ +} + S_m^{\ -},\ m \in \beta$$

最後，系統根據結果排序列出－ y>z>x，使用者因此可取得最符合需求的解決方案 y。

Rc_β^d	*d=q*	*d=t*	*d=c*
β=x	0.92	0.45	0.56
β=y	0.85	0.8	0.9
β=z	0.9	0.6	0.55
Rc_+^d / Rc_-^d	1/0	1/0	1/0
Weight	0.5	0.3	0.2

表 3 推薦決策陣列

Rc_β^d	*d=q*	*d=t*	*d=c*
β=x	0.46	0.135	0.112
β=y	0.425	0.24	0.18
β=z	0.45	0.18	0.11
Rc_+^d / Rc_-^d	0.5/0	0.3/0	0.2/0
Weight	0.5	0.3	0.2

表 4 權重化推薦決策陣列

	$S_\beta^{\ +}$	$S_\beta^{\ -}$
β=x	0.19123	0.49230
β=y	0.09810	0.52021
β=z	0.15811	0.49699

表 5 各推薦方案距正、負理想方案距離

	$C_\beta^{\ *}$
B=x	0.72023
B=y	0.84133
B=z	0.75864

表 6 各推薦方案距理想方案之相對接近距離

4.1.3. 適性化的信任關係網路

在許多信任機制爲基礎的推薦系統中，信任值多爲靜態，這種靜態信任值的機制不能有效反應因社會網路互動所帶來的影響，並且不會隨著社會網路的互動經驗而自動的擴張。在本研究中，經由推薦而進行實際互動後，使用者除了更新與該服務提供者的信譽評等外，與推薦者的信任關係也會動態的進化。這些的改變乃根據使用者互動後的實際滿意評價 Sr_β 與個別推薦者 *i* 提供之信譽評等 $Rp_{i\beta}$ 的相似度。

根據 C.H. Hsieh [5]，假設 $\tilde{s}_d = (s_d^1, s_d^2, s_d^3, s_d^4)$ 與 $\tilde{r}_d = (r_d^1, r_d^2, r_d^3, r_d^4)$ 爲兩個進行相似度比較的 fuzzy number，公式爲：$sim\left(\tilde{s}_d, \tilde{r}_d\right) = 1 - \frac{1}{2}\sqrt{\sum_{m=1}^{4}\left|s_d^m - r_d^m\right|^2}$。其值介於 0-1 間，趨近於 1 表相似度越高。Sr_β 與 $Rp_{i\beta}$ 可分別表示爲集合 $\tilde{S} = (\tilde{s}_q, \tilde{s}_t, \tilde{s}_c)$，集合 $\tilde{R} = (\tilde{r}_q, \tilde{r}_t, \tilde{r}_c)$，每個集合內的模糊值代表不同面向 d，各有不同的權重 Wd，因此兩集合相似度計算爲：$Sim\left(\tilde{S}, \tilde{R}\right) = \sum_{d=q,t,c} sim\left(\tilde{s}_d, \tilde{r}_d\right).Wd$，其值對應的模糊集如圖(7)。

如果推薦人屬於原有清單內的朋友，則根據 *Sim* 與表(7)的模糊規則集進行原本信任值之調整。其中只有高於一定程度的 *Sim* 才會進行調整，調整值分爲 *L,M,H*(圖 8)。對於原本經由社會網路取得的信任關係以及陌生人則以表(8)的模糊規則集建立新的信任值，同樣只有高於一定程度的 *Sim* 才會建立此新信任值，並將其加至朋友清單。

1. if *Sim* is *MS* then *Adjust* is *L*.
2. if *Sim* is *HS* then *Adjust* is *M*.
3. if *Sim* is *AS* then *Adjust* is *H*.

表 7 信任值調整模糊推論規則集

1. if *Sim* is *MS* then *Trust* is *ST*.
2. if *Sim* is *HS* then *Trust* is *MT*.
3. if *Sim* is *AS* then *Trust* is *HT*.

表 8 信任值建立模糊推論規則集

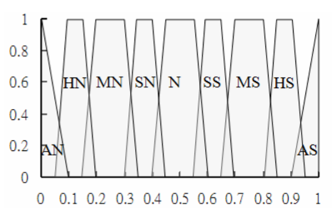


圖 7 Similarity fuzzy set

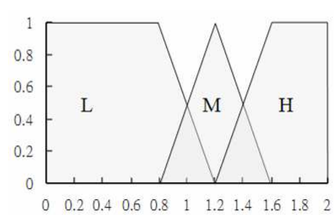


圖 8 Trust increase fuzzy set

4.2 Trust Messenger & Trust Blog

這兩個關鍵的網路社群應用，其信任機制的實作上的考量有共同之處：

4.2.1 Cold Start 的處理

Cold Start的問題發生於新使用者加入之時擁有太少與其他節點的信任值，造成他們被具有孤立(isolated)的現象。由於難以確定新使用者和現存使用者間的關係使得被孤立的新使用者無法得到良好品質的訊息 [13]。我們提出的解決的方法是利用網路中圖形(Graph)的概念，在社會網路中找到連結緊密的社群，從這些社群中找出連結程度最高的節點，做爲社群的代表人。新進的使用者可以利用這些代表人很快的與社群中的使用者做連結並發展自己的社會網路，進而加快cold start phase的速度。

4.2.2 搜尋的停止條件

在一個龐大的社會網路中，如果對於搜尋範圍不加限制，可能會過度拓展搜尋範圍。因此，我們訂定搜尋的範圍或者是搜尋停止的條件，來解決這個問題。

- 設定門檻

門檻(threshold)是判斷節點是否要合作的依據，如果高於信任值的門檻則節點合作，若低於門檻則不合作。在決定門檻的依據是建立於風險以及競爭的狀況[28]。我們將設立一個門檻，當搜尋到的節點傳回的信任值太小，我們就停止搜尋。這樣做不但可以避免過度搜尋的問題，也可有較佳的搜尋時間。信任度較高的節點，對於信任的遞減較有抵抗力，而信任度較低的節點則無法抵抗信任遞減，所以信任度較高的節點可以有較長的搜尋距離。

- 設定搜尋的距離

我們設定一個距離門檻，不管信任度的高低，我們都將搜尋一定的距離，在搜尋超過這個距離的時候，就停止搜尋。好處是搜尋的時間非常的固定，壞處是外我們也可能無法在範圍內找到我們想要的節點就停止搜尋。但這個問題可以透過訂定一個良好的距離解決，我們將範圍設定在 six degrees。

4.2.3 演算法

我們將演算法分成兩個部份，第一部份是尋找路徑，在尋找路徑當中，我們將連結到信任值過低的使用者的路徑去除，藉由門檻值避免過度的搜尋。第二部份是信任值計算，我們將利用尋找路徑中所儲存的樹狀圖作信任值的運算。信任值的計算方式，我們採取簡單的權重方式計算每條路徑信任值佔所有信任值的比例做爲他的權重。

- 社會網路路徑搜尋

變數	Mark	temppath	Finalpath	Currenti	Pathi
說明	標誌目標節點在出發節點中清單的號碼(初始值 0)	目前正在嘗試走訪的一條路徑	儲存所以確定可走到目標節點的路徑	目前 temppath 已經經過多少個節點(初始值爲-1)	目前已經找到多少條路徑可以從出發節點走到目標節點(初始值 0)

```
PathSearch(出發節點,目標節點){
    if(出發節點==目標節點)
        回傳錯誤”自己對自己的信任度不需要透過此種方式找”;
    else{
        if(checkCycle(出發節點){
            Mark =0;
            for(出發節點的每一個朋友節點){
                if(目前迴圈的朋友節點==目標節點)
                mark=此朋友在清單中的編號}
            if(mark!=0){
                if(currenti<5){
                    目前的出發節點與目標節點這條 arc 存入 temppath
                    currenti++;
                    將 temppath 這條路徑放入 finalpath 中
                    currenti--; //往回一個 level}
            }
            else{
```

```
if(currenti<5){
    for(出發點的每一個朋友節點){
        將出發節點到目標節點這條 arc 存入 tempptth
        currteni++
        PathSearch(目前迴圈的朋友節點,目標節點)
        if(currenti>-1){
            將 temppath 中第 currenti 項移除
            currenti--;                    }}}}}}}
```

■ 信任值計算:

```
float countTrust (String[][][] arc){
/*~ path[x][y][z] x  代表的是 arc 所在的階層， y 代表的是這條 arc 是 x 階層的第幾條，z 的大小爲[0,2]，0 爲 arc 聯結到的 source，1 爲 arc 聯結到的 target，2 爲 source 對 target 的信任值~*/
for ( int i = arc.length - 1; i >= 0; i--){
        // 從樹狀的底層往回推算至 source  最上面一層爲 0 階最下面一層爲 n-1 階
    for (int j = 0 ; j < arc[i].length ; j++) { //  搜尋此階層的每條 arc
if (arc的target不爲目標) {
for( int m = 0 ; m < arc[i+1].length ; a++ ) {
    if(i+1 階層第 m 條 arc 的 source 等於 i 階層的第 j 條的 target) ) {
        將此條 arc 的信任值存入 arcRate[]中}
for( int l = 0 ; l < arcRate.length ; l++) {
    divider = divider + arcRate[l];} //  計算出權重的divider
for( int h = 0 ; d < arcRate.length ; h++) {
  finalRate = finalRate + ((arcRate[h]/divider)*arcRate[h]);
  //  將每條arc的信任值乘上它的比重並加總
}}
```

五、結果與討論

如何從大量的資訊來源中，取得「可靠」的服務與資訊來源爲眾多網路應用的核心議題。找尋可靠且符合需求的服務來源對於使用者而言是一項成本，有效的推薦有助於線上商務的發展與運作。本研究以社會網路的人際關係，建立以信任機制爲基礎的 peer-to-peer 服務推薦系統。此服務推薦系統的基礎即爲信譽系統之概念，然而提供了更多不同面向與深度的考量，各形式的服務內容如檔案、資訊、同好社群、專家諮詢等，皆可藉由此系統的推薦機制取得可靠的服務來源，主要特色如下：

- 提供多面向觀點，人性化、直覺的回饋機制(圖9)，並考慮「時間」因子進行信譽評等。
- 以信任網路爲基礎，並考慮「可靠度」因子進行客觀衡量，藉由個人化設置（圖

10）提供多面向決策的個人化推薦（圖11）。

■ 能根據推薦結果而進行動態演化的信任網路。

藉由上述特色的建立，期使各形式的服務內容如檔案、資訊、同好社群、專家諮詢等。同時，藉由能因應實際網路互動而動態改變信任網路的機制，使此動態演化的信任網路，反饋至推薦深度與質量，提供更適性化、個人化且可靠的服務推薦。

圖 9 滿意評價回饋介面

圖 5 服務需求設置

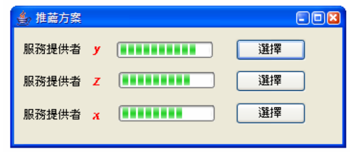


圖 11 推薦方案排名

藉由4.4節的演算法與機制設計，我們設計出在外觀上接近一般即時通訊軟體(如圖）但實質包含信任機制過濾（耳語系統，圖13）的通訊架構。

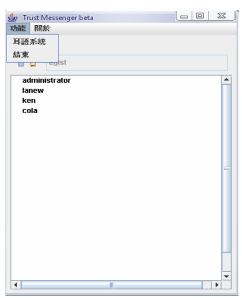


圖 12 Trust Messenger 系統主畫面

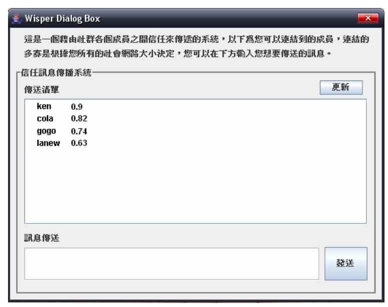


圖 13 耳語系統主畫面

在社會網路上做信任度的推算，有一個很大的問題就是當信任度需要計算時，系統處理時間過久，尤其是社會網路一旦擴張後，搜尋的時間將會提高很多，而學者因而提出了使用機率的方式做信任度推算，使用機率的信任度推算模型，可以縮短信任度推算的時間。此外在信任度的表示上，是否有更好的表示形式，讓使用者可以更準確的評量對朋友的信任值，且讓使用者能更直觀的掌握對某位朋友的信任度。都是可以進改進的地方。因此，我們未來的研究工作除了將各運作細節進行更精準的實驗與調整外，也會將此推薦系統嵌入更多的應用實例，了解各系統參數對不同應用的影響與效用，提出可參數化的通用推薦平台。

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計畫成果自評

本專題原為兩年計畫，第一年工作為分散式信譽系統基礎建設與應用服務，第二年為經濟與賽局模型建構與分析。因國科會最後只核定一年執行期限，原計劃第一年工作已順利完成，正式完成項目與計畫初預期項目之情形如下：

1 廣泛文獻探討與開發工具調查

我們已發表的兩篇研討會論文[附錄 1 & 2]分別在「研究背景」與「相關文獻」都有這些內容之記載。領域涵蓋「信任網路與推論機制」、「社會網路」、「信譽系統」、「模糊邏輯」、「語意網路及其上之信任機制」。而開發工具與方法則包括人工智慧中的「模糊邏輯」，多準則決策中的「TOPSIS」工具。實作上的 Java 程式語言與 XML 應用。

2 回饋介面,資料管理與信任引擎設計

論文[附錄 1]即針對這部份的研究結果公開發表。應用人工智慧中的模糊邏輯使得多面向、人性回饋介面(feedback interface)得以實現；信任推論引擎（trust inference engine）也以模糊推論為基礎，並考慮可靠因子以及能隨互動結果適性擴展的信任網路；而在 data management 上，以多準則決策中的「TOPSIS」工具及方法協助推薦資訊的聚合與呈現。

3 整合研究內容至現今線上社群/社會網路應用

論文[附錄 2]針對目前熱門的線上即時通訊進行信任機制整合。我們利用信任機制建立起一個有別於傳統的聯絡人清單的聯絡人網路，聯絡人從自己的朋友這個範圍，增加到朋友以及朋友的聯絡人清單。我們的通訊系統中並利用這些使用者的信任值，作為判斷是否傳播訊息的依據。

目前本專題研究成員將整理研究成果，並將最後成果投稿國際期刊。而原訂第二年最主要的工作項目包括發展競局理論與社會網路模型來研究在信任網路中合作行為之動態學，以及分析網路信譽機制的管理與經濟效率性，則因為核准期限之限制（核准年限為一年）而無法依照原計畫進行。此經濟分析的部份是我們認為能夠大幅超越過去學界於信任機制領域研究之處，同時也是本研究室核心，並且是全球資訊管理學界頂尖學府如MIT、CMU目前專注的領域。因此，如核准時限與原訂計畫相同，我們相信可以做出更創新、突破的研究。

附錄

1. “Trust Based Intelligent P2P Recommendation System”, Li, Y.-M and C.-P. Kao, Proc.11th Conference on Artificial Intelligence and Applications, Kaohsiung City, Taiwan, December, 2006.

2. “Trust Based Instant Messaging System”, Li, Y.-M., T.-Y. Li and J.-C. Chen, Proc. 9th Conference on Information Management Practice, Yunlin , Taiwan, December, 2006.

A Report for the Attendance of International Conference JCIS 2006

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This year 2006, JCIS (Joint Conference on Information Sciences) has been held successfully in Kaohsiung City, Taiwan, Oct. 8-11. International Conference JCIS is a multidisciplinary meeting encompassing conferences, workshops and symposiums that highlight emerging science and technology related to intelligent machinery and systems. For more than a decade, the conference has encouraged information dissemination and the exchange if ideas among researchers in the diverse yet interconnected fields of information sciences.
JCIS 2006 consists of the following 5 tracks:

• 11th International Conference on Fuzzy Theory and Technology (FTT)
• 9th International Conference on Computer Science and Informatics (CSI)
• 7th International Conference on Computer Vision, Pattern Recognition and Image Processing (CVPRIP)
• 5th International Conference on Computational Intelligence in Economics and Finance (CIEF)
• 4th International Conference on Photonics, Networking and Computing (PNC).

This year, CIEF 2006 continues the tradition of featuring applications of computational intelligence to solve real problems in economics and finance. It focuses on new techniques and/or novel applications with state-of-the-art numerical methods, econometrics, and AI methodologies applied to economics or finance. In addition to regular technical sessions, CIEF 2006 will also have organized 14 special sessions, 4 tutorial sessions as well as keynote speeches. Relevant topics include, but not limited to, Agent-Based Computational Economics, Artificial Stock Markets, Behavioral Finance, Experimental Economics, Simulation of Social Processes, Evolutionary Game and Industrial Organization, Financial Engineering, Financial Data Mining, Trading Strategies, Hedging Strategies, Portfolio Management, Derivative Pricing, Term Structure Models, Financial Time Series Forecasting and Analysis.

The authors submitted a paper, *A Fuzzy Rule-based Bargaining Model for Online Group Purchasing*, to a CIEF's special session, *Fuzzy decision and Management*, and the paper was accepted. This paper utilizes *fuzzy logic* to develop a *bargaining* model for online group purchasing. The model supports buyers to make group decision to set up their bargaining strategy; instead of using static rules, buyers can customize their fuzzy rule base that can infer to produce negotiation proposals to bargain with sellers. Our experiments show that (1) the prototype system with the fuzzy function is easy to use; (2) people enjoy online bargaining for better prices; (3) they think that online bargaining is very important and inevitable for electronic markets in the future.

After the presentation of this paper at the special session, the author was asked a good question: *"Is there any correlations between the linguistic variable A, group's satisfaction* *degree to seller's proposal, and linguistic variable B, the ratio for the difference between buyers' and seller's proposals."* Since both variables are related to the proposal from the seller, it seems that there is more or less correlation between them. To avoid any correlation, our future work is therefore to find another linguistic variable to replace, probably, linguistic variable B, so that the automatically generated proposal for buyers will be hopefully much closer to the expectation of buyers. So far, the author has come out with another linguistic variable, the intension to successfully finish the bargaining with a deal within a short time. The stronger the intension is, the larger the concession should be. However, it needs experiments to show whether it is a good linguistic variable or not in the future.

A Fuzzy Rule-based Bargaining Model for Online Group Purchasing

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Abstract

Online group purchasing or *collective purchasing* is the activity in which people who desire to buy the same merchandises join together so that they can negotiate with sellers for a better price through Internet.

This paper utilizes *fuzzy logic* to develop a *bargaining* model for such activities. The model supports buyers to make group decision to set up their bargaining strategy; instead of using static rules, buyers can customize their fuzzy rule base that can infer to produce negotiation proposals to bargain with sellers.

Experimental results show that (1) the prototype system with the fuzzy function is easy to use; (2) people enjoy online bargaining for better prices; (3) they think that online bargaining is very important and inevitable for electronic markets in the future.

Keywords: Group Purchasing, Collective Purchasing, Bargaining, Fuzzy Logic, Electronic Commerce

1. Introduction

Online group purchasing or collective purchasing is the activity in which people who desire to buy the same merchandises join together [1] so that they can bargain [2][9] with sellers for a better price through Internet.

However, the service of group bargaining for online group purchasing has not really been provided by commercial electronic stores yet. Currently, prices for online group purchasing are only decided by price-quantity functions or (price, quantity) tables which are defined by sellers [3][4][5]. Although this approach reduces the complexity of online group purchasing, the prices are still decided by sellers after all. Therefore, we think that buyers should have the right to group together and bargain for better prices, just like that in traditional markets.

For this sake, we develop an online bargaining model [10] that supports buyers to make group decision and automatically generate proposals to bargain with sellers. We utilize *fuzzy logic* [6][7][8] to develop the model. It first fuzzifies buyers' input, and then uses fuzzy rule base to infer to a fuzzy concession rate, which will be defuzzified to decide how much to concede in the next proposal.

In addition, the bargaining model is adaptive. It supports buyers to set up their bargaining strategy at the beginning, including deciding some important factors for bargaining, and even customizing their own fuzzy rule base. This is because every individual buyer is different, so is the group they form. A static rule base is not appropriate to use for every group.

A prototype system [10] for this model has been developed for experiments. Results show that the prototype with the fuzzy function is easy to use; people enjoy online bargaining and they believe that online bargaining is very important and inevitable for electronic markets in the future.

2. The Bargaining Model

The bargaining model for group purchasing is illustrated by the flow chart in Figure 1. It is described from the buyer's point of view. Each numbered task in the figure is described as follows:

1. **Set up buyers' bargaining strategy (i) determine price related values.**
   Every buyer inputs their (a) bid for the first proposal to the seller; (b) highest acceptable price for the merchandise; (c) most concession rate between two consecutive proposals. The constraint is that the value of (a) should be less than that of (b); the value of (c) is a rate which is during [0,1]. With these three classes of input from all individuals, we get the minimum value of each class for the group to use in the bargaining. These three values are called (1) the

bid of the *group's* first round proposal; (2) the *group's* highest acceptable price; (3) the *group's* most concession rate between two consecutive proposals.

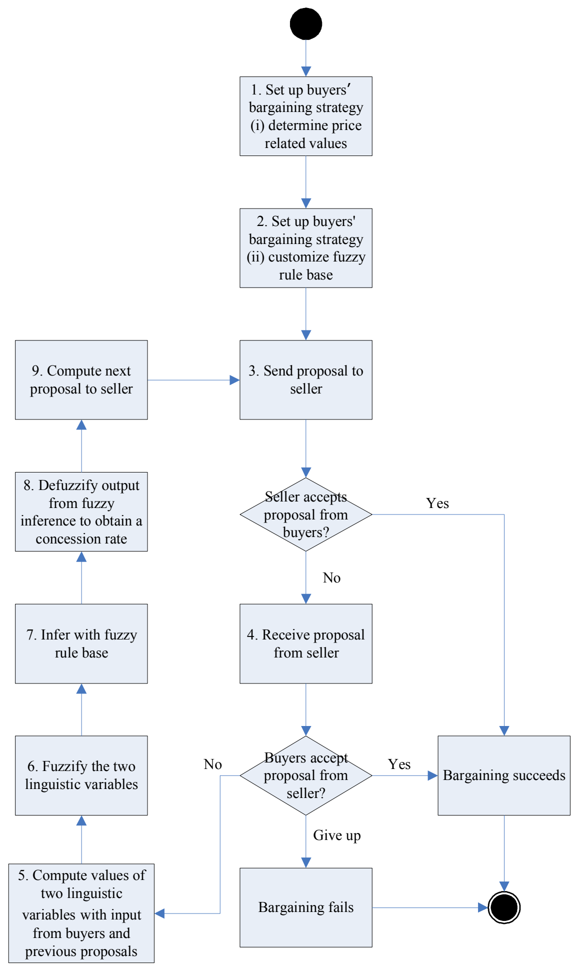

Fig. 1: The bargaining process for buyers

2. Set up buyers' bargaining strategy (ii) customize fuzzy rule base

The fuzzy rule base is established with three variables. (1) *A*: the group's satisfaction degree to the proposal from the seller; (2) *B*: the ratio for the difference between buyers' and seller's proposals; (3) *C*: the group's concession rate. These three variables are called *linguistic variables* of the fuzzy system; the first two serve as the input of the fuzzy inference machine and the last as its output, whose upper bound is the group's most concession rate between two consecutive proposals.

In this task, each buyer first considers which of the first two variables has more impact on the last one. Then, the technique of "Conjoint Analysis" is employed to compute weight w_i of these two variables, and these weights will be used to establish the customized fuzzy rule base. This is described as follows:

Each of the three linguistic variables has a *linguistic term* set consisting of 5 terms: NB (Negative Big), NS (Negative Small), ZO (Zero), PS (Positive Small) and PB (Positive Big), and they are mapped to integers 1, 2, 3, 4 and 5, respectively. We use function *f*: {NB, NS, ZO, PS, PB} → [1,5] to represent the mapping.

The format of each inference rule is

If (*A* is *x*) & (*B* is *y*) Then (*C* is *z*),

where *A* and *B* are the input linguistic variables; *C* is the output variable; $x, y, z \in$ {NB, NS, ZO, PS, PB}. Therefore, the establishment of the fuzzy rule base is to finish the table as shown in Table 1. The formula to obtain the value of *C* is:

$$z = f^{-1}(g(w_1 * f(x) + w_2 * f(y))),$$

where *g* represents the function to round the input number to the nearest integer; $w_1 + w_2 = 1$. Table2 shows a customized rule base.

Table 1: The empty fuzzy rule base

A / *C* / *B*	NB	NS	ZO	PS	PB
NB					
NS					
ZO					
PS					
PB					

Table 2: A customized fuzzy rule base

A / *C* / *B*	NB	NS	ZO	PS	PB
NB	NB	NS	NS	ZO	PS
NS	NB	NS	ZO	ZO	PS
ZO	NS	NS	ZO	PS	PS
PS	NS	ZO	ZO	PS	PB
PB	NS	ZO	PS	PS	PB

3. Send proposal to seller

The sent proposal is either the first round proposal from Task 1 or the other round proposal from Task 9. The content of the proposal at least contains the bid and the amount of the merchandise the group wants to purchase. Since the proposal contains the purchase amount, buyers can freely join or quit the group during the bargaining.

4. **Receive proposal from seller**
If the seller agrees on the proposal, the bargaining succeeds and the process terminates; otherwise, the seller will send an anti-proposal to buyers.
If all buyers accept this anti-proposal, the bargaining succeeds and the process terminates; if buyers cannot or do not want to continue for some reason, the bargaining is given up.

5. **Compute two linguistic variables with input from buyers and previous proposals**
With the anti-proposal from the seller, each buyer will input their satisfaction degree to this proposal. The degree is represented by integers from 0 to 10; 0 means the least satisfaction level and 10 the most satisfaction level. Linguistic variable *A*, group's satisfaction degree, is computed as follows:

$$\boldsymbol{A} = (\sum \mathrm{Sat}_i * \mathrm{Am}_i) / \sum \mathrm{Am}_i,$$

where Sat_i and Am_i are the satisfaction degree and purchasing amount of buyer i, respectively. Linguistic variable *B*, the ratio for the difference between buyers' and seller's proposals, is formulated as follows:

$$\boldsymbol{B} = \mathrm{Ps}_i - \mathrm{Pb}_i / \mathrm{Po},$$

where Ps_i is the seller's proposed price and Pb_i is buyer's bid for the *i*th-round proposal; Po is the original price of the merchandise.

6. **Fuzzify the two linguistic variables**
This is the first step of the fuzzy system. This step is to transform the crisp values of linguistic variables into grades of membership for linguistic terms of fuzzy sets. In this fuzzy system, each linguistic variable is designed with 5 linguistic terms {NB, NS, ZO, PS, PB}. Each linguistic term has a membership function that is used to associate a grade to the linguistic term. The membership functions of the linguistic variables *A* and B can be designed as in Figure 2. For example, for A = 8.5, the grades of membership for these 5 linguistic terms {NB, NS, ZO, PS, PB} are {0, 0, 0, 0.6, 0.4}, while for B = 0.2, the grades are {0.2, 0.8, 0, 0, 0}.

7. **Infer with fuzzy rule base**
This is the second step of the fuzzy system. Infer with the customized fuzzy rule base produced in Task 2. The inference method used is *max-product* method. The output of this method is the grades of membership for the 5 linguistic terms of linguistic variable *C*.

The *max-product* method has two stages: (1) generate the product of the grades of membership; (2) select the maximum value as the grades of membership for each linguistic term. For example, given grades of membership {0, 0, 0, 0.6, 0.4} and {0, 0, 0, 0.8, 0.2} for linguistic variables *A* and *B*, respectively, the result of the first stage of *max-product* method is shown in Table 3, where $C_{ij} = A_i * B_j$. After the second stage, the grades of membership {0, 0, 0, 0.48, 0.32} for linguistic variable *C* are obtained because 0 is the maximum grade of membership for NB, NS and ZO, 0.48 for PS and 0.32 for PB.

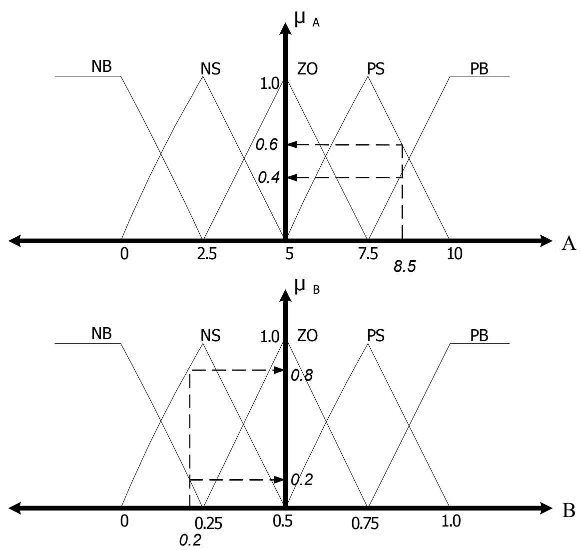

Fig. 2: Membership functions of linguistic variables *A* and *B*

Table 3: Inference with max-product method

A / C / B	NB (0)	NS (0)	ZO (0)	PS (0.6)	PB (0.4)
NB (0)	NB(0)	NS(0)	NS(0)	ZO(0)	PS(0)
NS (0)	NB(0)	NS(0)	ZO(0)	ZO(0)	PS(0)
ZO (0)	NS(0)	NS(0)	ZO(0)	PS(0)	PS(0)
PS (0.8)	NS(0)	ZO(0)	ZO(0)	PS (**0.48**)	PB (**0.32**)
PB (0.2)	NS(0)	ZO(0)	PS(0)	PS (0.12)	PB (0.08)

8. **Defuzzify output from fuzzy inference to obtain a concession rate**
This is the last step of the fuzzy system. The defuzzification method adopted is *Center of Gravity* method. The output of this method is a crisp value of a linguistic variable, the x-axis position of the gravity center of some areas

which are derived from the grades of membership of the linguistic variable.

For this case, the output is a crisp value of linguistic variable *C*, the group's concession rate, denoted by r_{i+1}. The rate is used to compute the bid for the group's *(i+1)*th-round proposal.

For example, assume the *group's* most concession rate between two consecutive proposals is 0.5. The membership functions of linguistic variable *C* is shown in Fig. 3. Given the grades of membership {0, 0, 0, 0.48, 0.32} for linguistic variable *C*, apply the Center of Gravity method to defuzzify and obtain a crisp value 0.39.

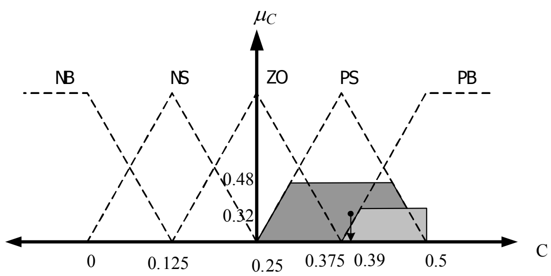

Fig.3: Membership functions of linguistic variable C

9. Compute the next proposal to seller

The buyers' next proposed bid for the *(i+1)*th-round proposal is denoted by Pb_{i+1}. It is calculated by

$$\mathbf{Pb_{i+1} = Pb_i * (1 + r_{i+1})},$$

where Pb_0 is the bid of the *group's* first-round proposal generated in Task 1. After that, go to Task 3 to send out the next proposal that at least contains Pb_{i+1} and the amount of the merchandise the group wants to purchase.

3. Conclusion

The contribution of this paper is the approach that we proposed for the online bargaining of group purchasing. A prototype system, shown in Fig. 4, for this model has been developed for experiments. Results show that the prototype with the fuzzy function is easy to use; people enjoy online bargaining and they believe that online bargaining is very important and inevitable for electronic markets in the future. However, the disadvantage is that the time group bargaining takes is a little bit longer.

Our future work is to improve the approach so that it has a better quality to compute the bid of proposals which is much closer to the common will of the group members.

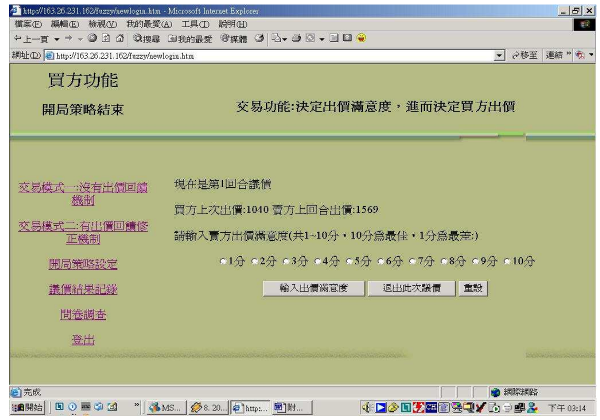

Fig. 4: A prototype bargaining system for experiments

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