Negotiation tools for industrial procurement

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intelligent software

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What is strategic sourcing?

Sourcing@isoco: Quotes

Summary

Future work

- Strategic sourcing is the identification, evaluation, negotiation, and configuration of products and services to ensure that a company can establish the most efficient global value chain
- Strategic sourcing ranges from simple sourcing of indirect goods and services to more complex sourcing of direct materials and services

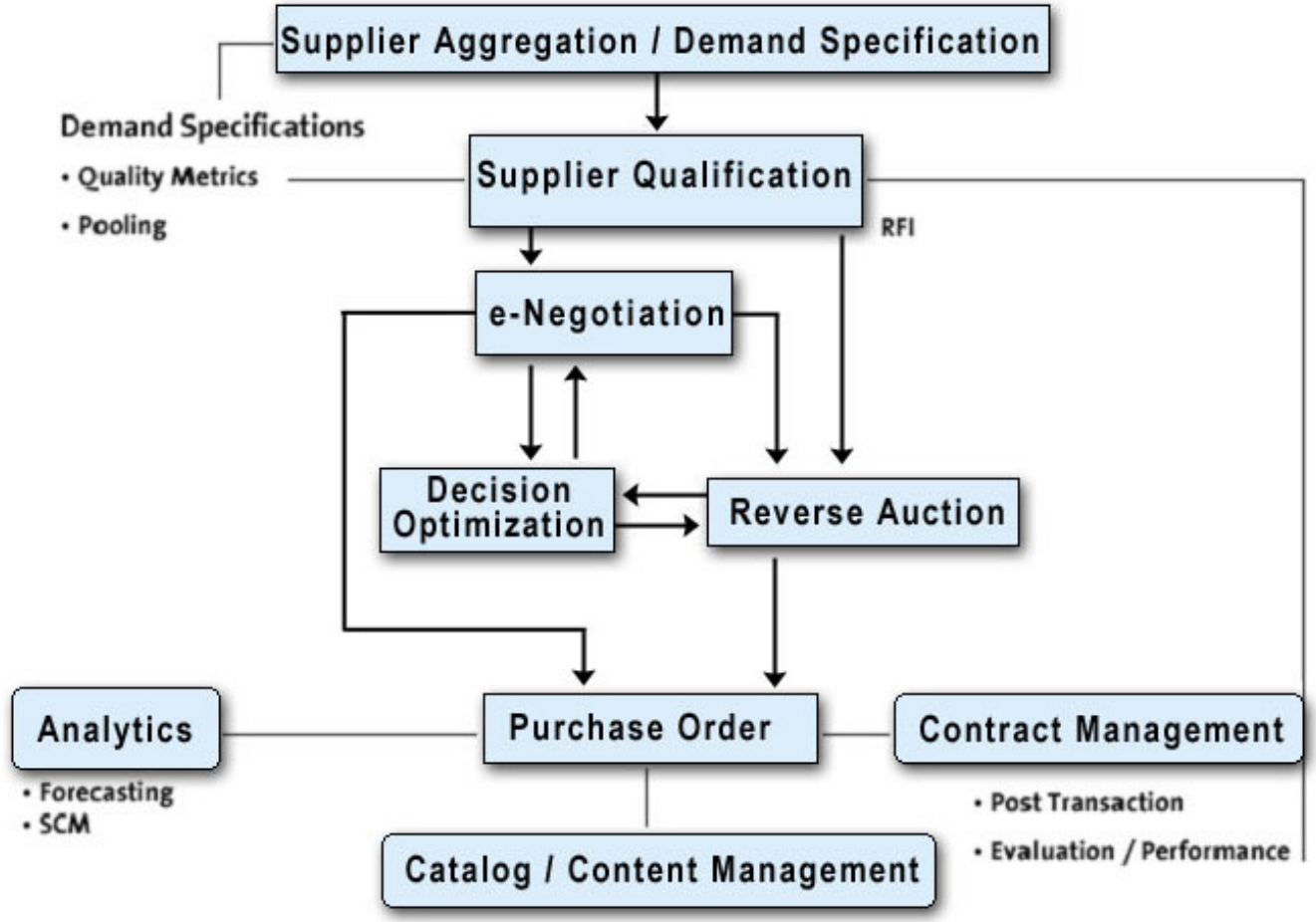
Current reality of sourcing

- 75% of companies rate their ability to benefit from the sourcing process as only *fair* or *poor*.
- Why? Most companies still utilise a convoluted mix of phone calls, faxes, e-mails and snail mail.
- 80% of professional buyers' time invested on administrative tasks.
- NO TIME FOR STRATEGY!!!

Source: Aberdeen Group May 2001

Sourcing tools save time, lower overall costs and allow buyers to concentrate on the most important task: *strategy*.

Strategic sourcing solution (e-sourcing) components



Strategic sourcing solutions facilitate better matches between buyers and sellers to yield value maximisation, produce savings, and superior products.

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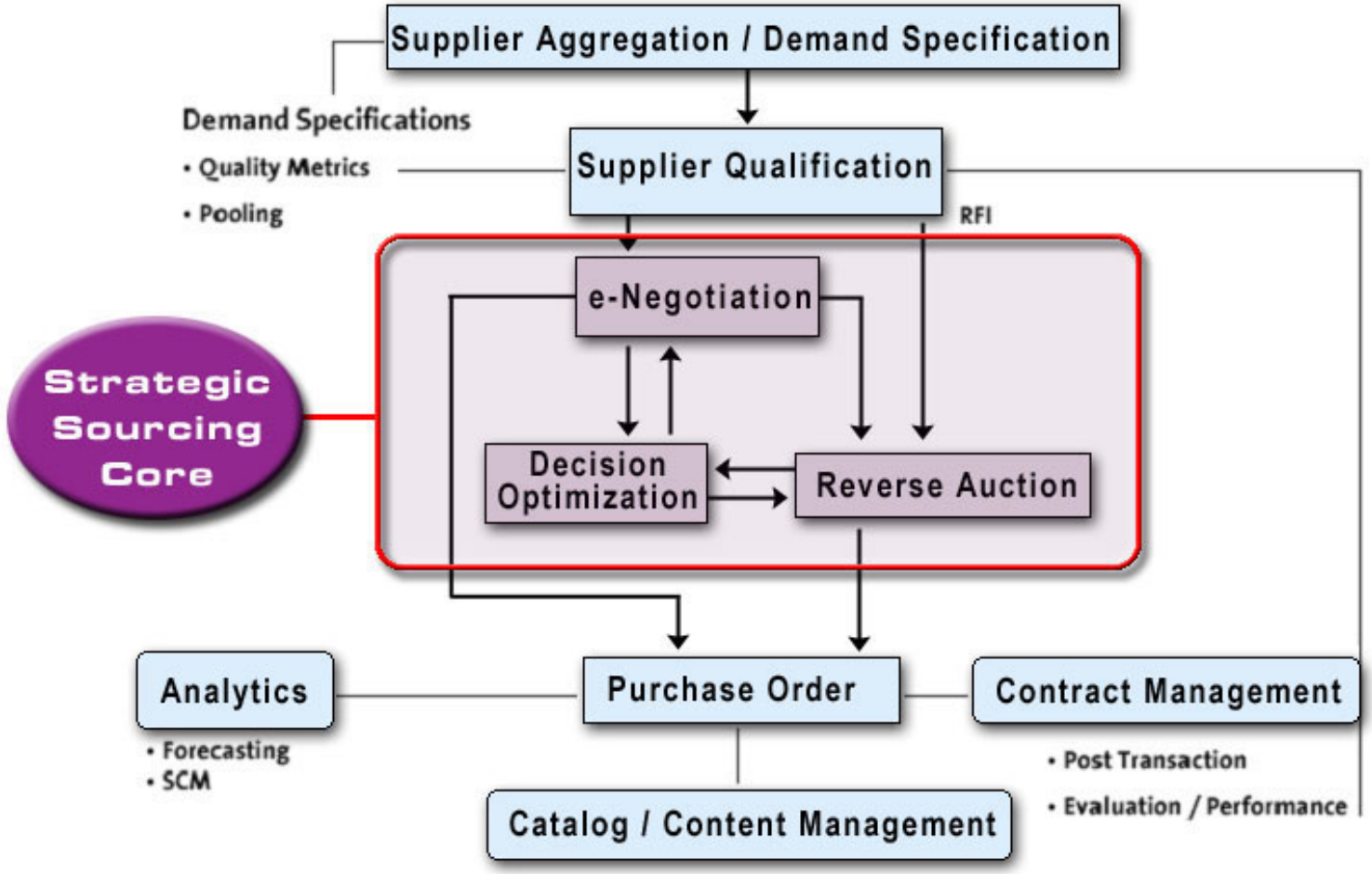
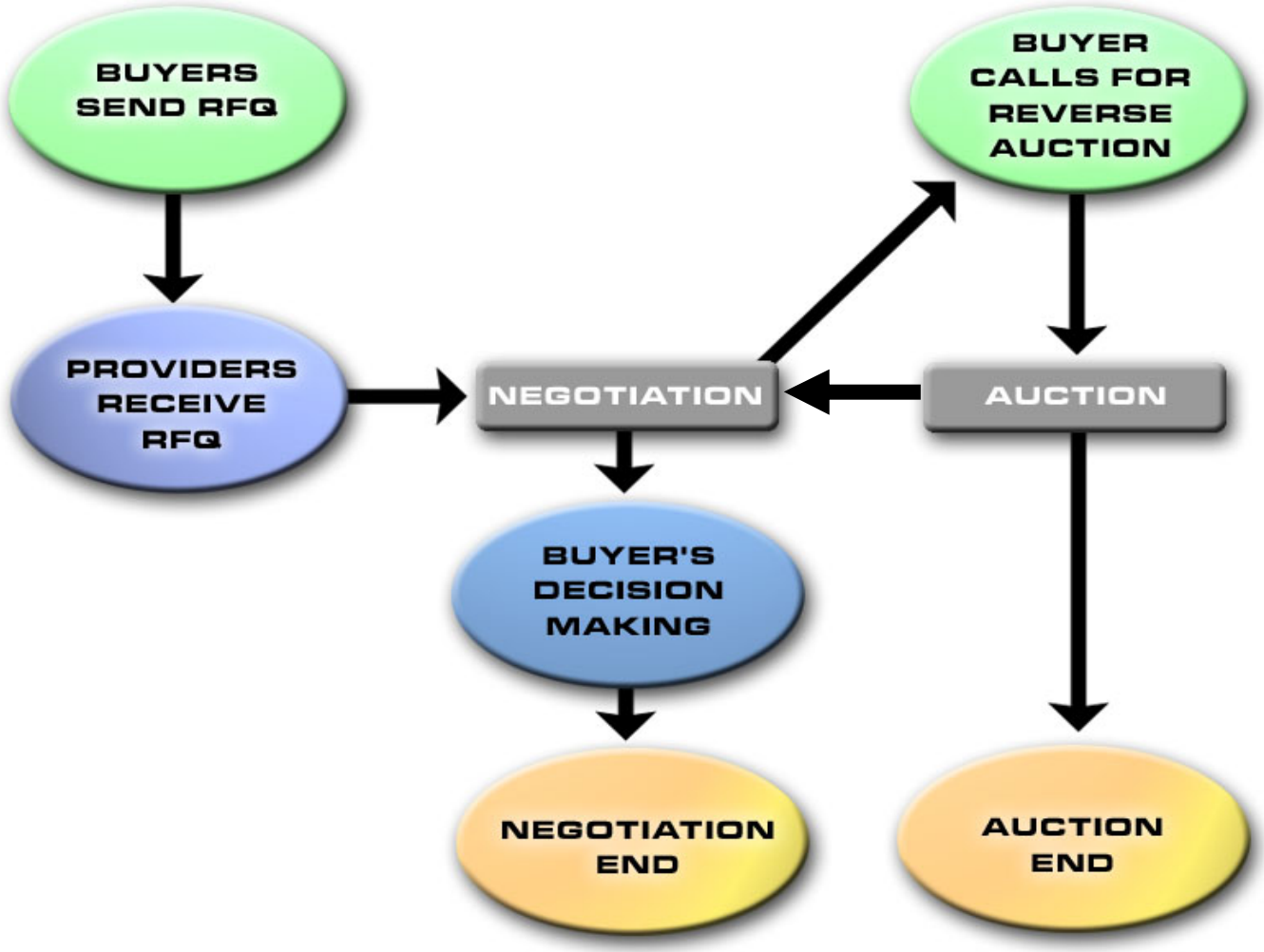


Enabling negotiation and auctioning of differentiated goods and services is key to achieve sourcing benefits.

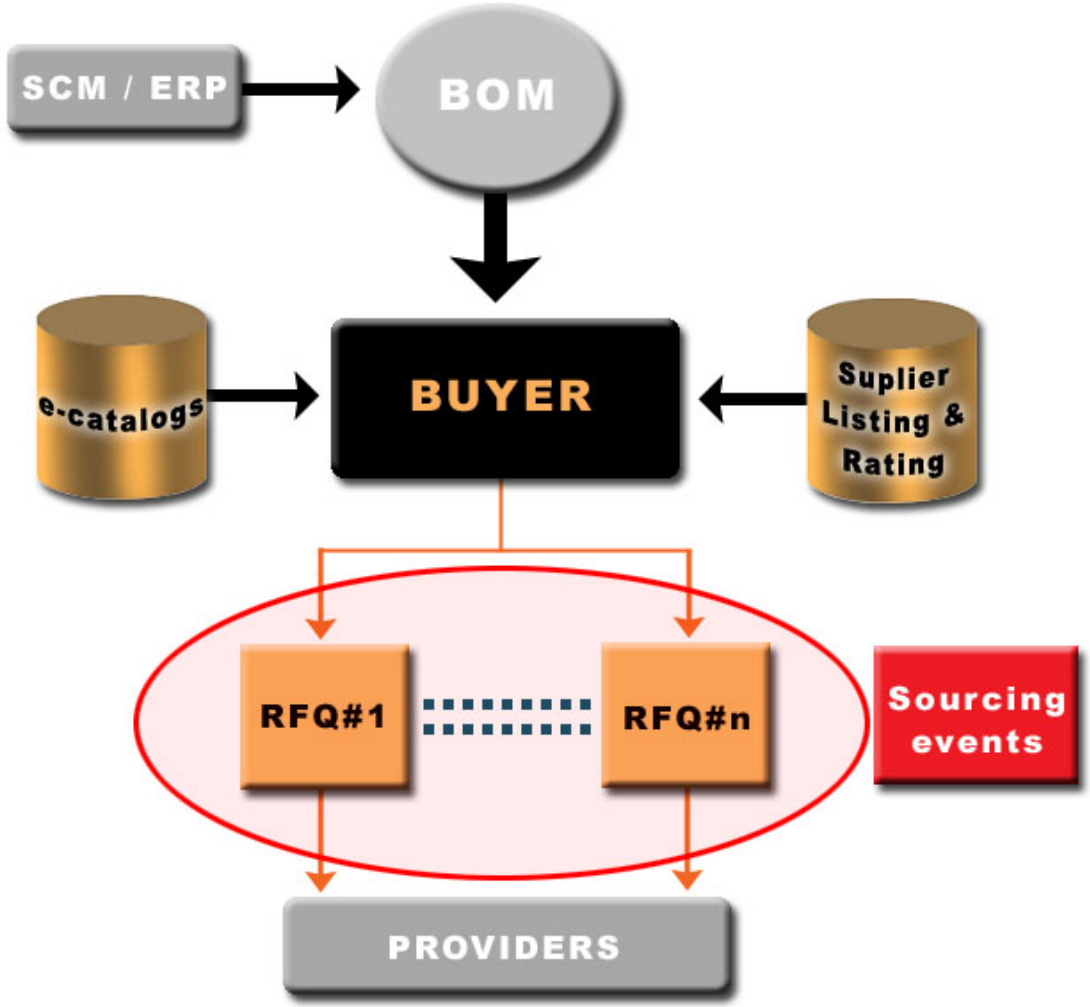
Reverse auctions and negoauctions



Quotes allows to select the negotiation mechanism ("pure" negotiation, reverse combinatorial auction, *negoauction*) that best fits partners' business

- **BOM (bill-of-material).** Multi-item sourcing event.
- **Commodity.** Undifferentiated services and goods (electricity, car hiring, cleaning services)
- **Catalogue.**
- **Custom part.** Highly customisable RFQ for direct goods with multiple attributes (foam, oil, etc.).

BOM RFQ



Decision support required to help professional buyers determine the best set of offers in complex RFQs.

What is strategic sourcing?

Sourcing@isoco: Quotes

- Scoring (RFQs,offers,counteroffers)
- Winner determination
- Bidding rules

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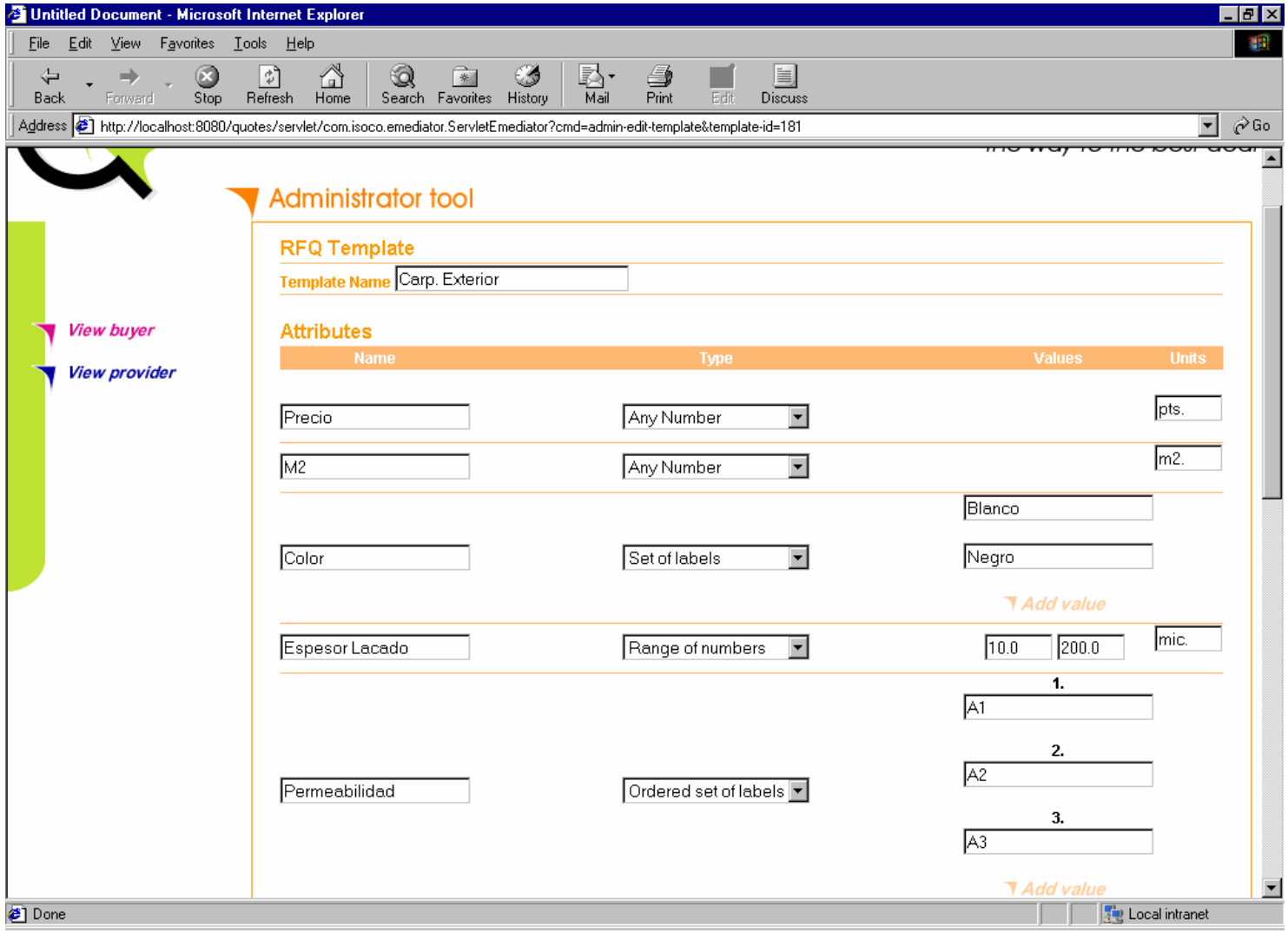
§ **Domain specification through templates.** Product and service templates define a common language for attributes

- **Name**
- **Units**
- Domain value **types** specify values each attribute can take on

Type	Description
“NUM”	Any numerical value
“RANGE”	Range of numbers
“SET”	Set of labels
“OSET”	Ordered set of labels
“TEXT”	Free text

Negotiation Templates



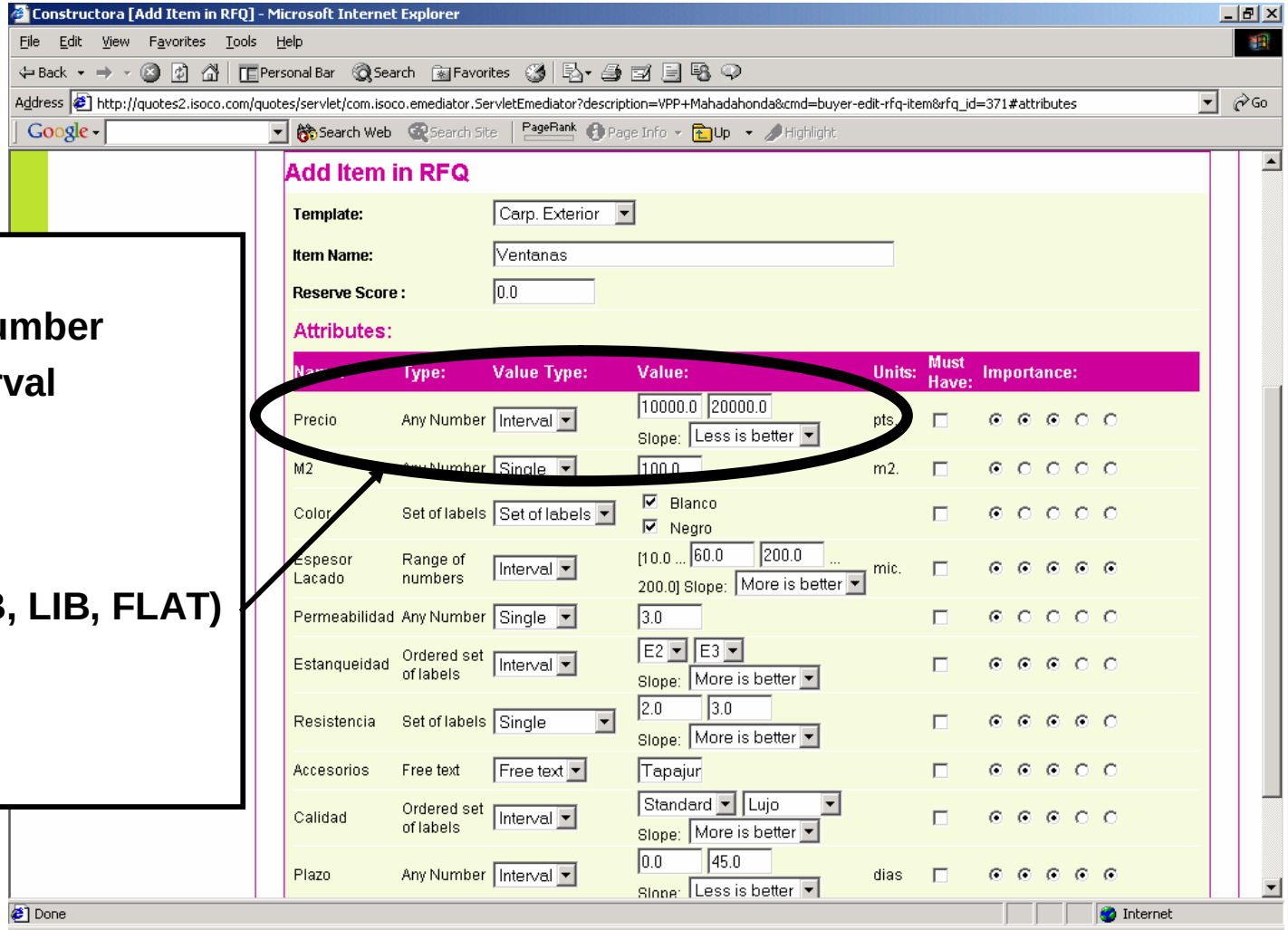
§ **RFQ definition through item templates**: RFQ defines buyer's preferences for each item:

- Type of preferred values (point, range, set, text)
- Values
- Must have flag
- Importance

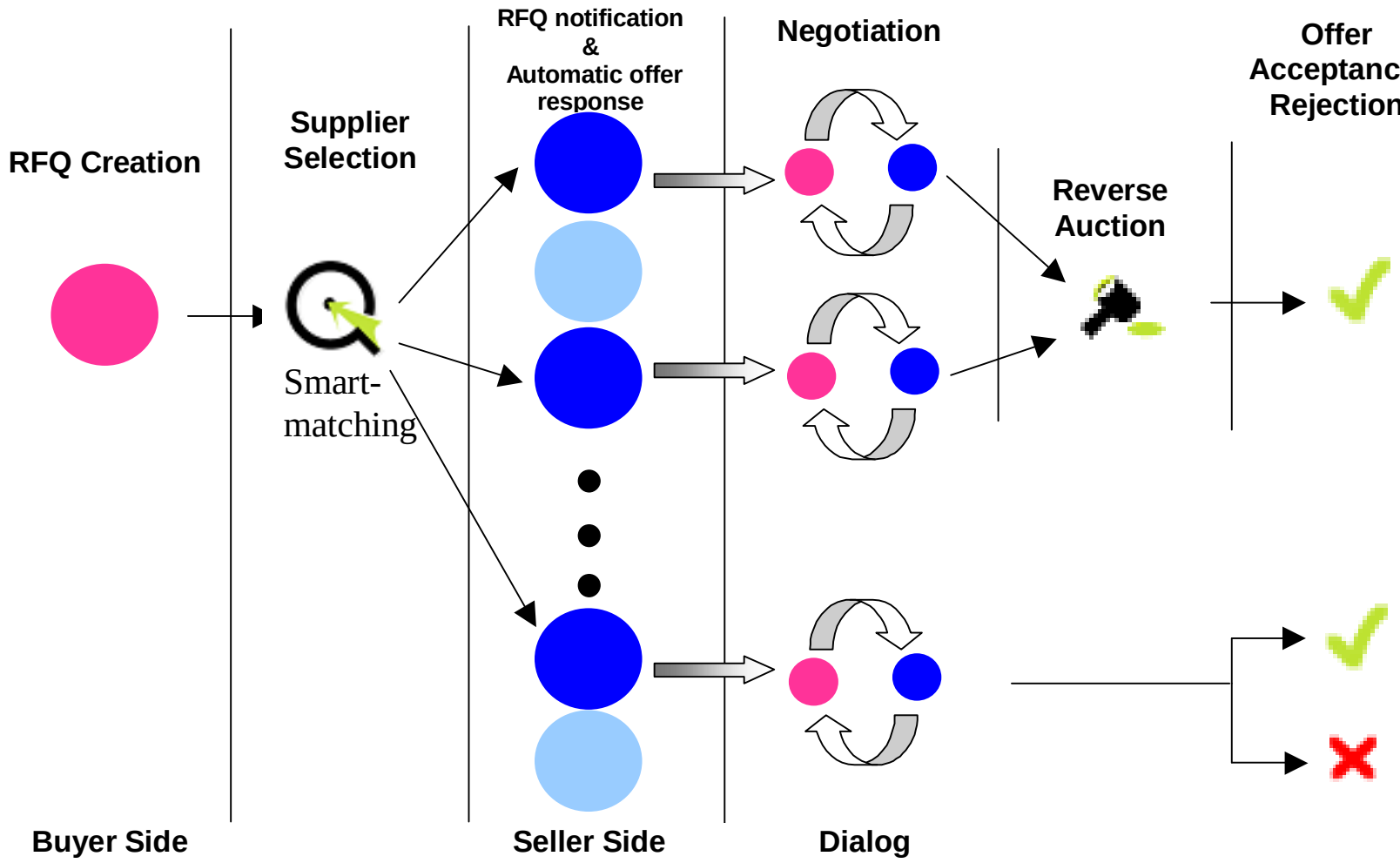
Template attr. type	RFQ attr. type	Attribute value description
"NUM"	"POINT"	One numerical value
"NUM"	"RANGE"	Numerical Interval
"RANGE"	"POINT"	One numerical value
"RANGE"	"RANGE"	Numerical Interval
"SET"	"POINT"	One label
"SET"	"SET"	Set of labels
"OSET"	"POINT"	One ordered label
"OSET"	"RANGE"	Interval of ordered labels
"TEXT"	"TEXT"	Free text

Price example:

- domain: any number
- RFQ type: interval
- RFQ value:
  - min value
  - max value
  - slope (MIB, LIB, FLAT)
- units
- must have
- importance



Structured Negotiation



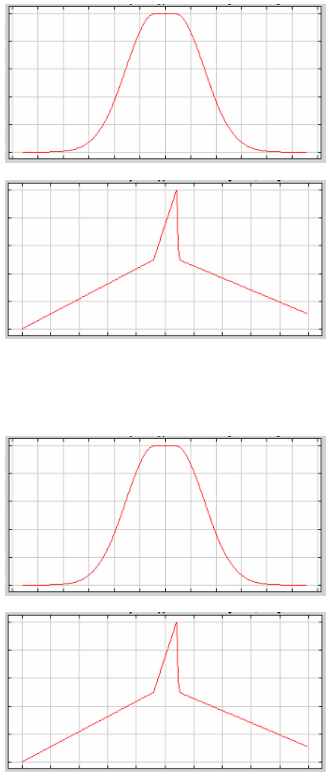
Quotes allows to reproduce traditional negotiations over the web by allowing buyers and providers to exchange offers and counteroffers.

Offer scoring@buyer

RFQ
-Item1
-Attribute1
-...
-AttributeN
-Item2
-Attribute1
-Attribute2
-Item3
- ...

Offer Prov. A
-Item2
-Attribute1
-Attribute2

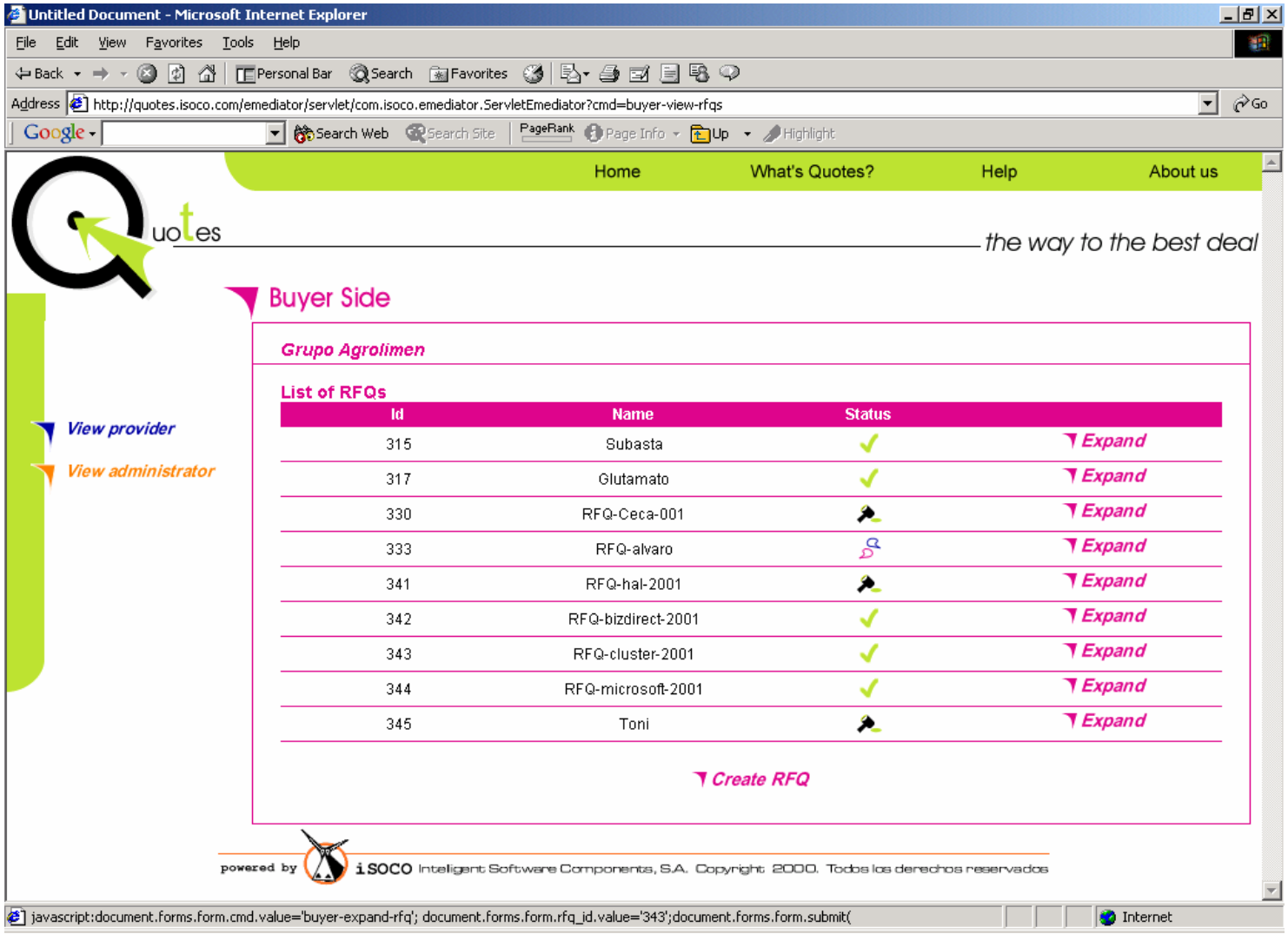
Offer Prov. B
-Item2
-Attribute1
-Attribute2



Score computation

Offer Order

1st. Offer P. B
2nd. Offer P. A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View administrator
Grupo Agrolimen
List of RFQs
Id
Name
Status
315 Subasta Expand
317 Glutamato Expand
330 RFQ-Ceca-001 Expand
333 RFQ-alvaro Expand
341 RFQ-hal-2001 Expand
342 RFQ-bizdirect-2001 Expand
343 RFQ-cluster-2001 Expand
344 RFQ-microsoft-2001 Expand
345 Toni Expand
Create RFQ
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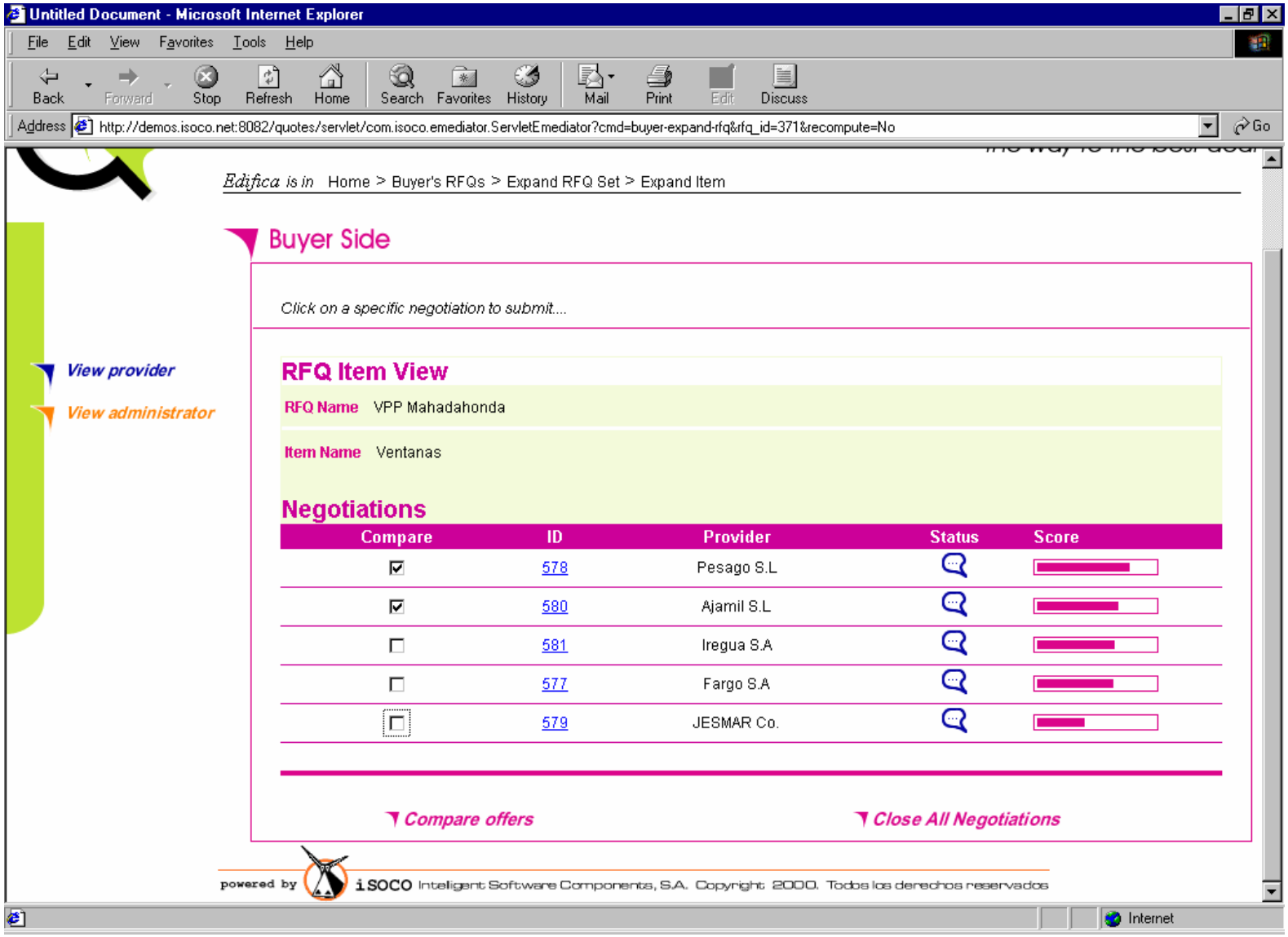
Internet

Offer scoring@buyer



1. **Fuzzy functions *F* represent preferences** for each attribute using:
   - Domain value type specification:
     - Fixed interval of possible values (“RANGE”, “SET”, “OSET”)
     - Unlimited possible values (“NUM”)
   - Preference values:
     - Type:
       - “POINT”
       - “RANGE” (min, max, slope)
       - “SET”
     - Values (numbers or labels)

2. **Membership value for each offer attribute** value i is afterwards computed using the corresponding preference fuzzy function F_i

$$score(attribute \quad i) = F_i(offer\_value_i)$$

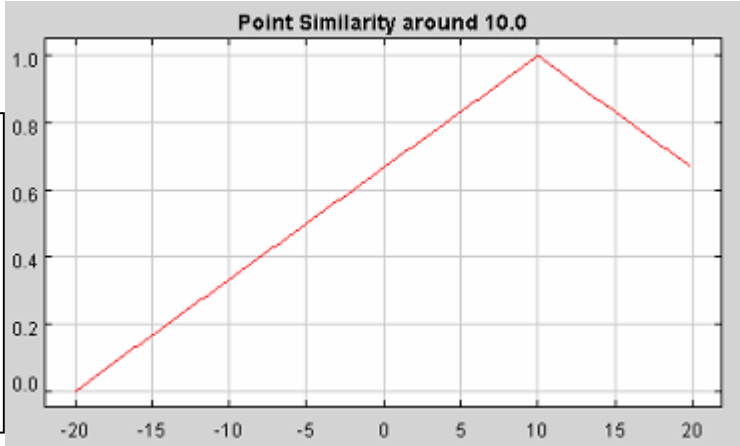
3. **Membership values are weighted** with the importance of the preference attribute w_i when computing each item scoring

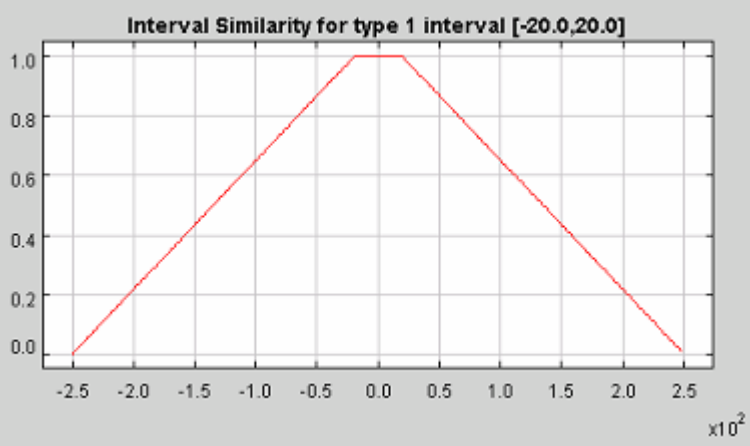
$$score(item\ j) = \sum_{attribute\ i=1}^{N} \frac{score(attribute_i) \cdot w_i}{N}$$

4. **Offer scoring** is a weighted combination of item scorings

$$score(Offer) = \sum_{item\ j=1}^{M} \frac{score(item_j) \cdot w_j}{M}$$

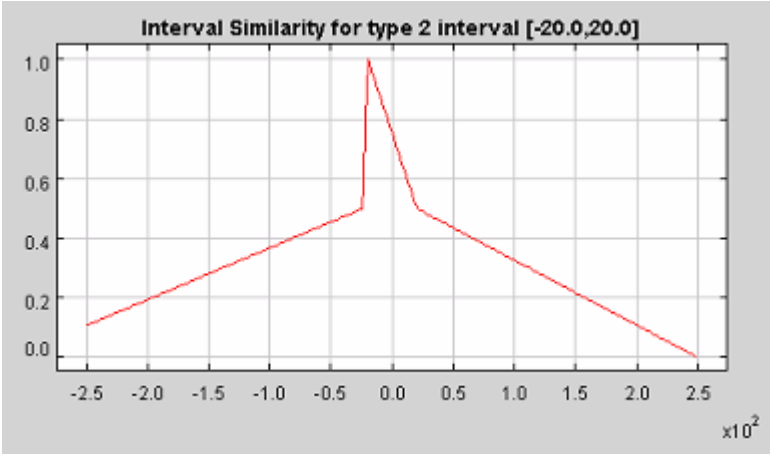
Domain: fixed interval RANGE [-20,20]
Preference:
type = POINT,
value = 10
$F(10)=1$, $F(-20)=0$, $F(20)=0.66$

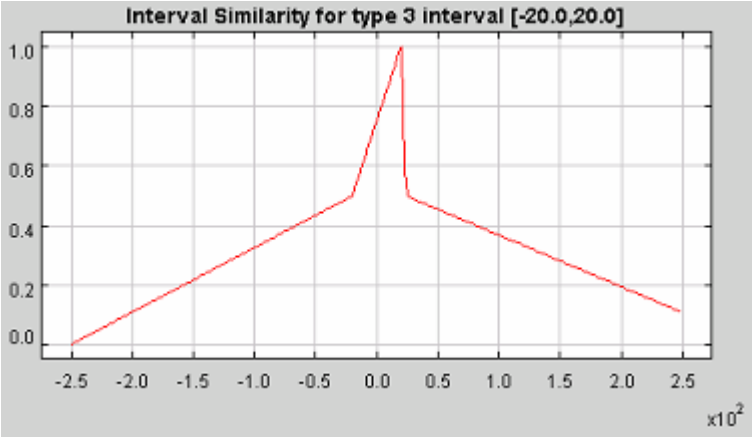




Domain: fixed interval RANGE [-250,250]
Preference:
type = RANGE,
value = [-20,20] FLAT
$F([-20,20])=1$, $F(-250)=0$, $F(250)=0$

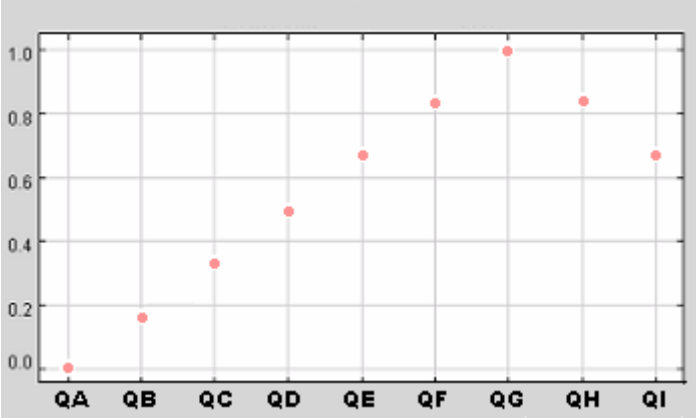
Domain: fixed interval RANGE [-250,250]
Preference:
type= RANGE,
value= [-20,20] LIB
F(-20)=1, F(20)=0.5, F(-24)=0.5

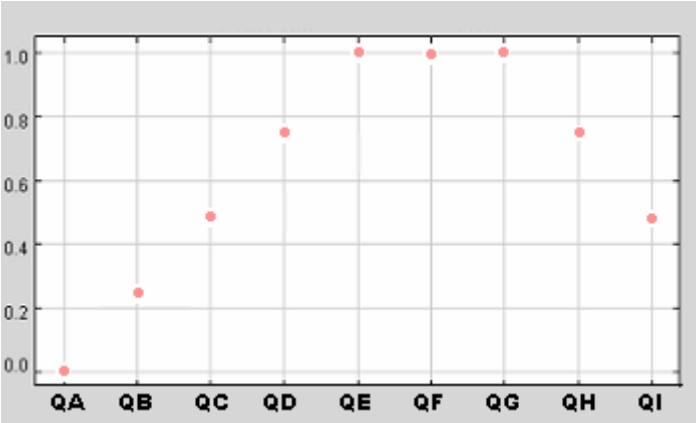




Domain: fixed interval RANGE [-250,250]
Preference:
type= RANGE,
value= [-20,20] MIB
F(-20)=0.5, F(20)=1, F(24)=0.5

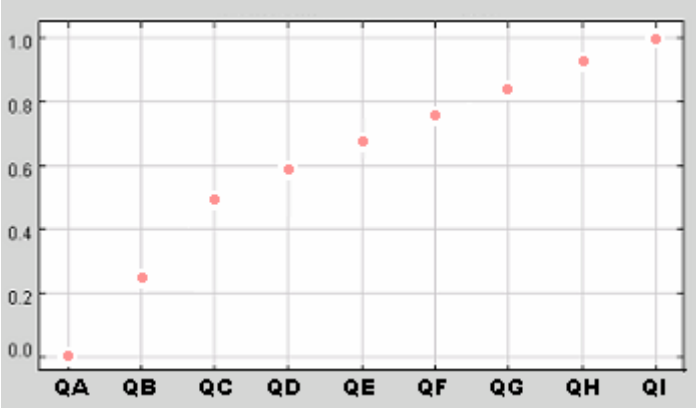
Domain: fixed interval OSET [QA,QI]
Preference:
type= POINT,
value= QG
F(QG)=1, F(QA)=0, F(QI)=0.66

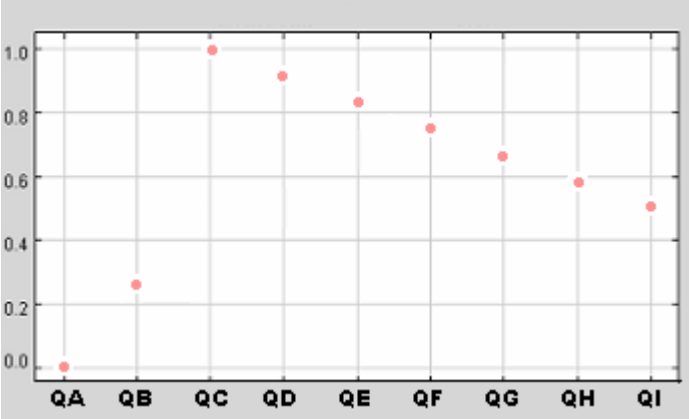




Domain: fixed interval OSET [QA,QI]
Preference:
type= RANGE,
value= [QE,QG] FLAT
F(QE)=1, F(QG)=1, F(QA)=0, F(QI)=0.5

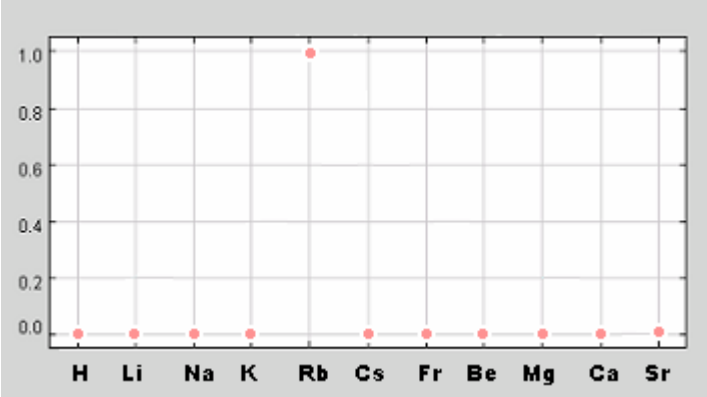
Domain: fixed interval OSET [QA,QI]
Preference:
type= RANGE,
value= [QC,QI] MIB
F(QC)=0.5, F(QI)=1, F(QB)=0.25, F(QA)=0

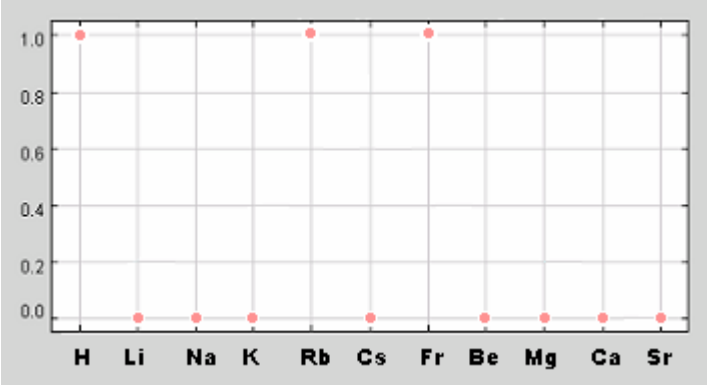




Domain: fixed interval OSET [QA,QI]
Preference:
type= RANGE,
value= [QC,QI] LIB
F(QC)=1, F(QI)=0.5, F(QB)=0.25, F(QA)=0

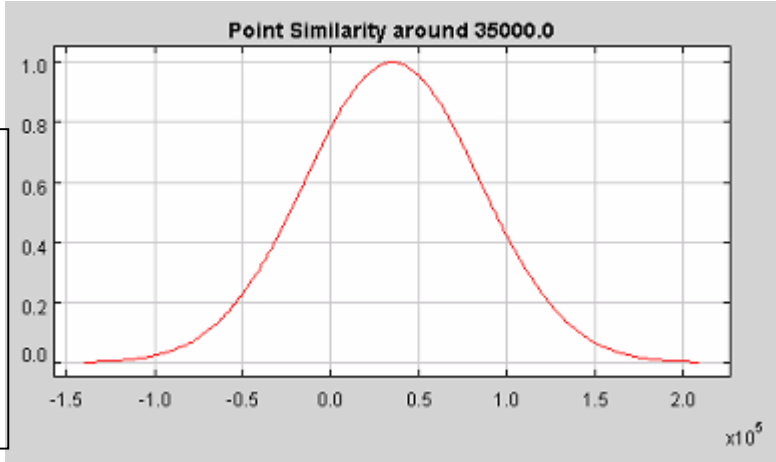
Domain: fixed interval SET
Chemical Elements
Preference:
type= POINT,
value= Rubidium Rb
F(Rb)=1, F(H)=0, F(Fr)=0 , F(Li)=0

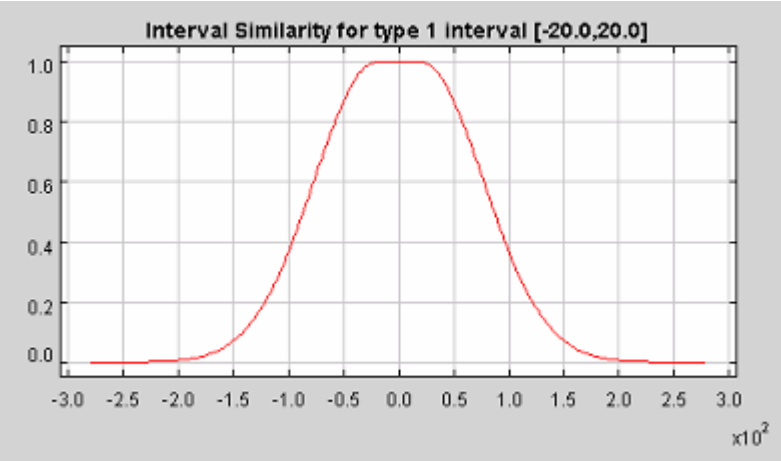




Domain: fixed interval SET
Chemical Elements
Preference:
type= SET,
value= {H, Rb, Fr}
F(H)=1, F(Rb)=1, F(Fr)=1 , F(Li)=0

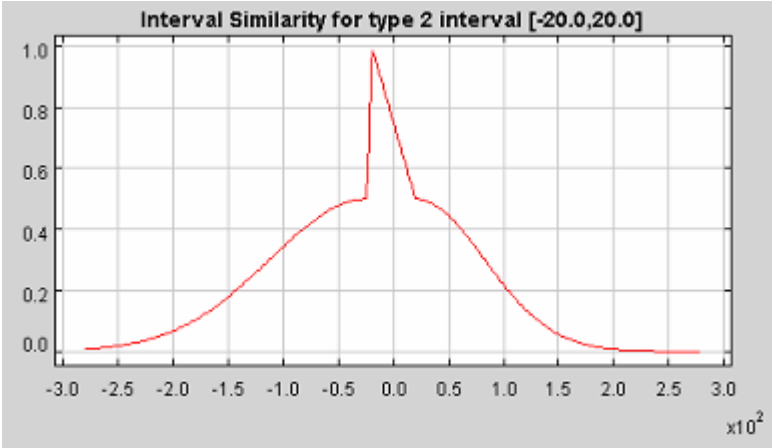
Domain: non-limited NUM
Preference:
type= POINT,
value= 35000
F(35000)=1

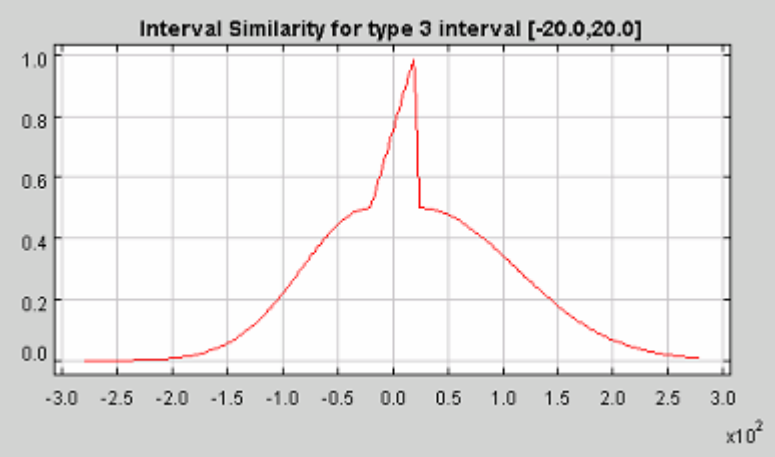




Domain: non-limited NUM
Preference:
type= RANGE,
value= [-20,20] FLAT
F([-20, 20])=1

Domain: non-limited NUM,
Preference:
type= RANGE,
value= [-20,20] LIB
F(-20)=1, F(20)=0.5, F(-24)=0.5



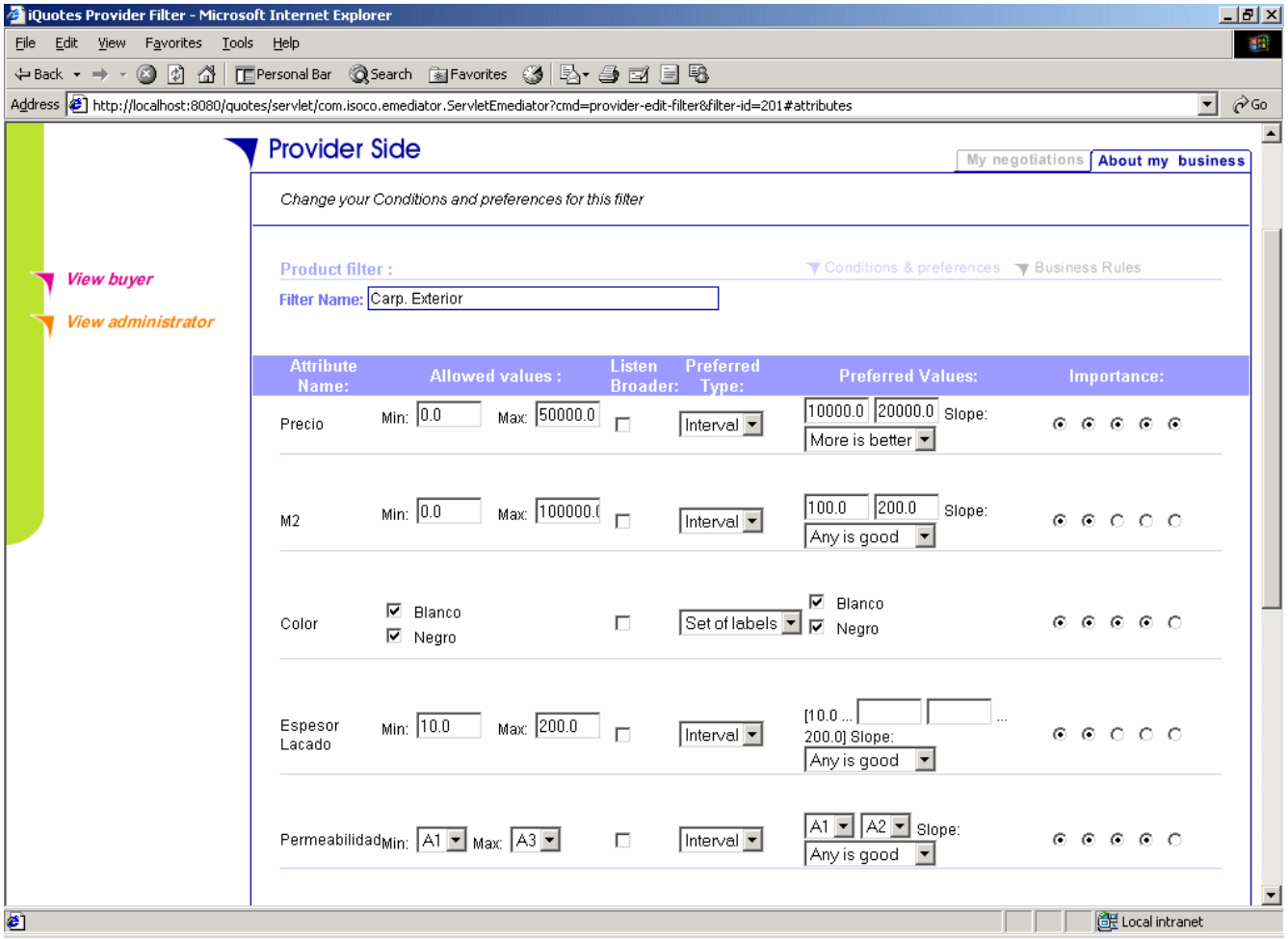


Domain: non-limited NUM,
Preference:
type= RANGE,
value= [-20,20] MIB
F(-20)=0.5, F(20)=1, F(24)=0.5

Fuzzy scoring computation

- When computing the scoring of an Offer with reference to a RFQ:
  - Multiple values in an RFQ attribute mean they are different preferred options (i.e., they are OR-combined) ,
  - Offer attribute values are always single (for different options a provider must generate different offers)
  - Computed membership values $F_i(offer\_value_i)$ satisfy:
    - They are ≥ h if *Offer_value* belongs to the preferred values in the RFQ
    - Otherwise, they are < h. Nevertheless, the entire offered item will be rejected if the buyer selects the Must Have condition associated to the attribute value.

§ **Providers define their business rules using item templates.**
For each produced item, they define preferences.

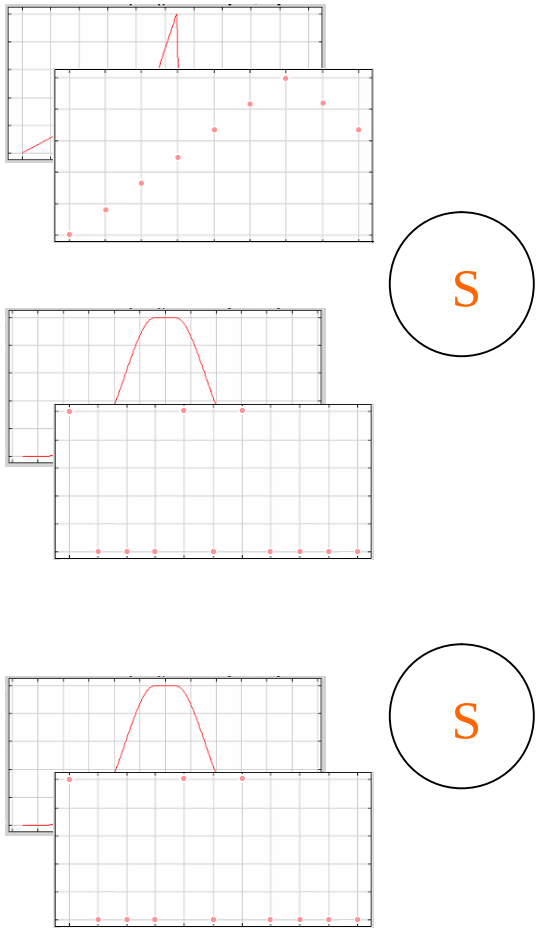


Business Rule for Item1
- Attribute1
- ...
- AttributeN

Business Rule for Item2
- Attribute1
- ...
- AttributeM

RFQ Buyer A
-Item1
-Attribute1
-...
-AttributeN
-Item2
-Attribute1
-...
-AttributeM

RFQ Buyer B
-Item2
-Attribute1
-....
-AttributeM

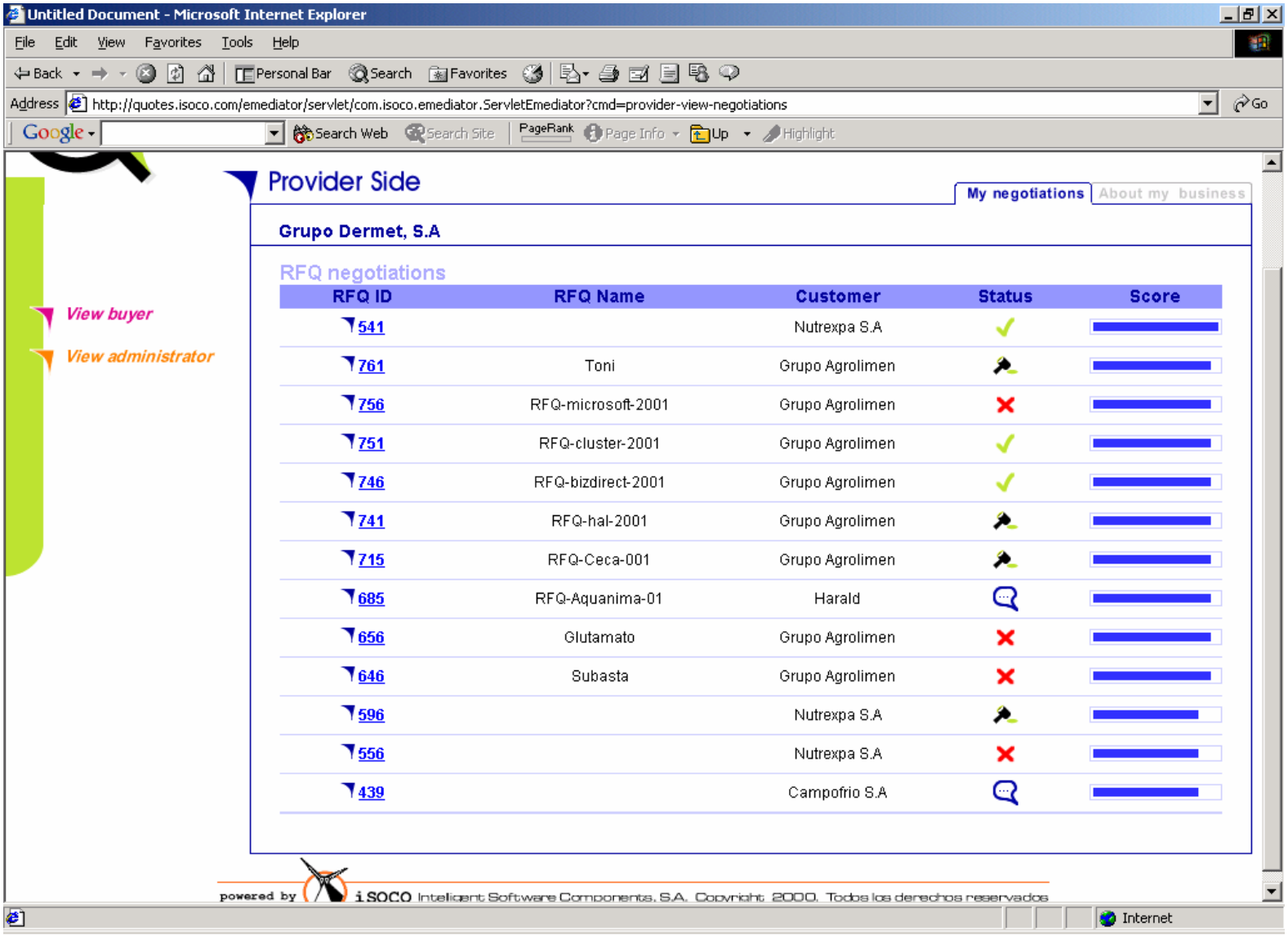


Score computation

RFQ Order:

1. RFQ B
2. RFQ A

RFQ Scoring@provider



Fuzzy scoring computation. Summary

- When computing the scoring of an RFQ with reference to the business definition the **same scoring algorithm is used but**:
  - Multiple values in the preferences of a produced item attribute mean they are different preferred options (i.e., they are OR-combined)
  - Multiple values in an RFQ attribute mean they are different asked options (i.e., they are OR-combined).
  - **Membership values are computed choosing the best membership value for each set of OR-combined asked options.**
  - Only RFQs asking for values that are produced will be considered unless the provider does not explicit otherwise (i.e. by selecting the Will Listen Broader option associated to each attribute).

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- Winner determination
- Bidding rules

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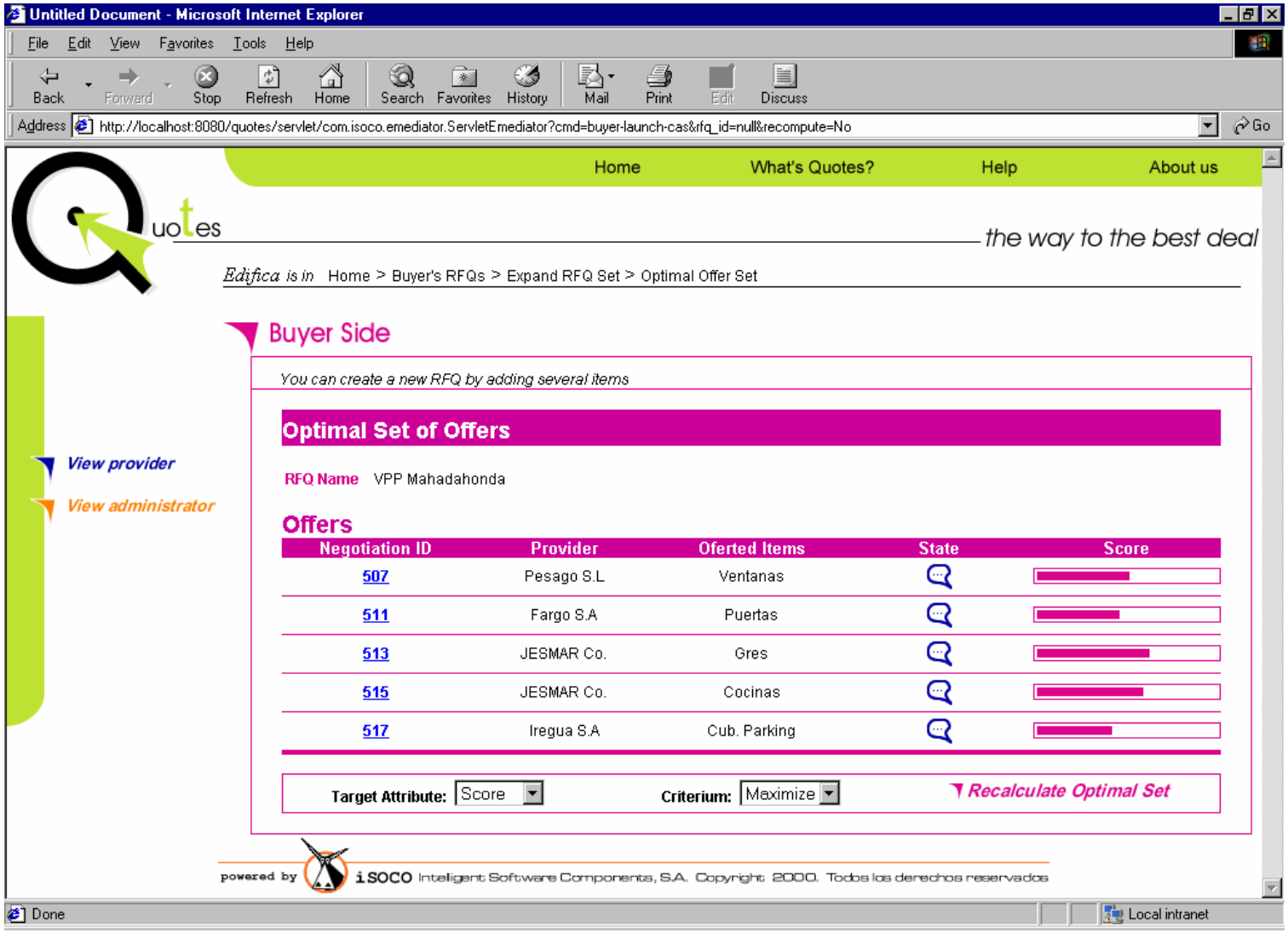
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Buyer Side
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View administrator
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Offers
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Pesago S.L
Ventanas
511
Fargo S.A
Puertas
513
JESMAR Co.
Gres
515
JESMAR Co.
Cocinas
517
Iregua S.A
Cub. Parking
Target Attribute: Score
Criterium: Maximize
Recalculate Optimal Set
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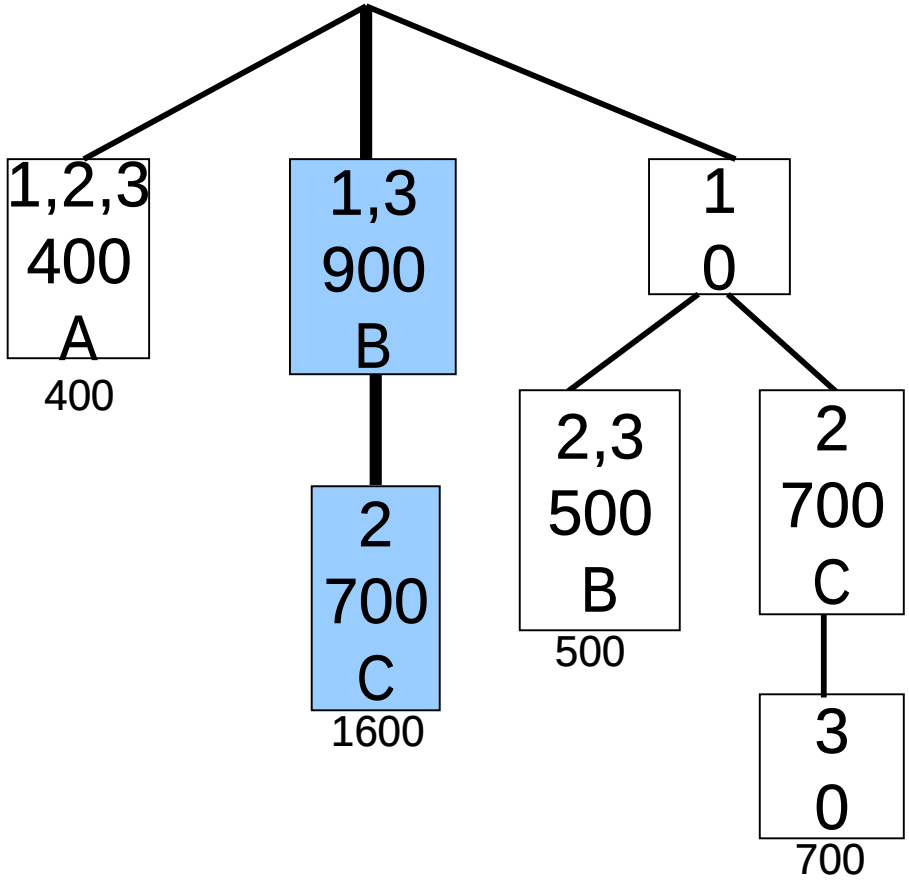
Local intranet

Score maximisation search tree

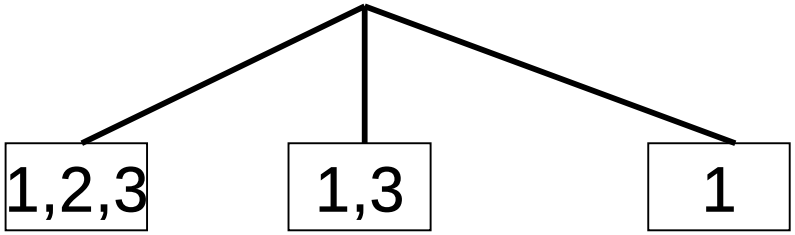


Score maximisation search tree

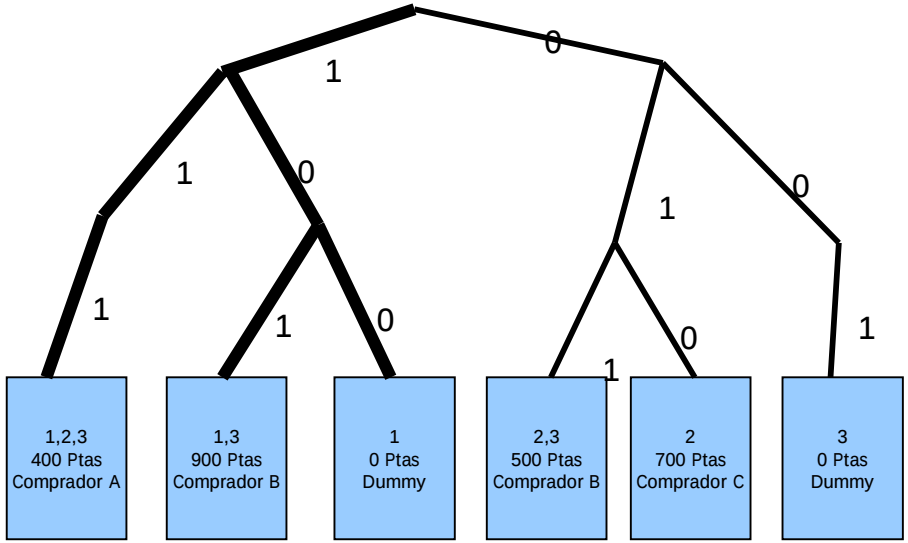
Stopmask

1	2	3
Must	*Any*	*Any*

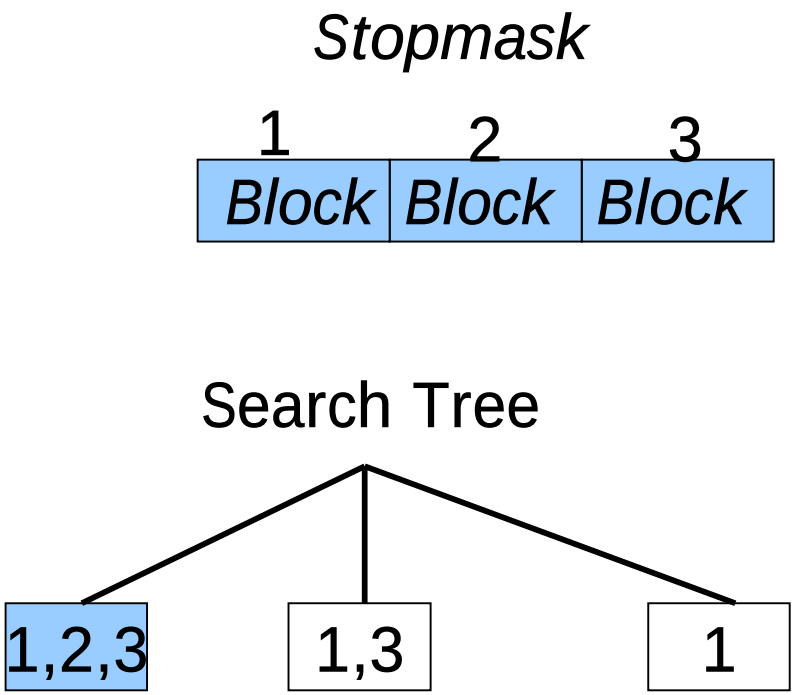
Search Tree

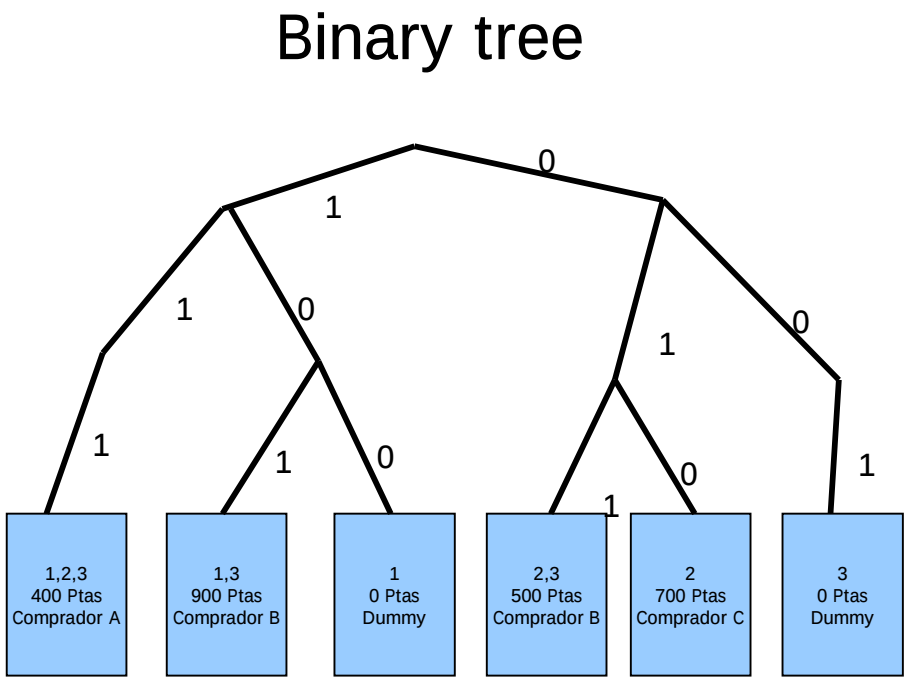


Binary tree

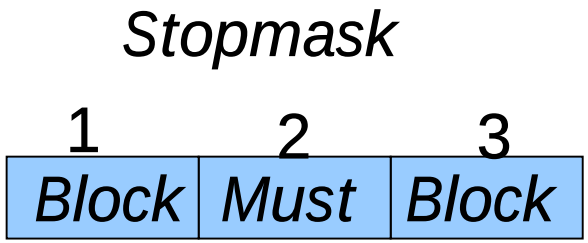


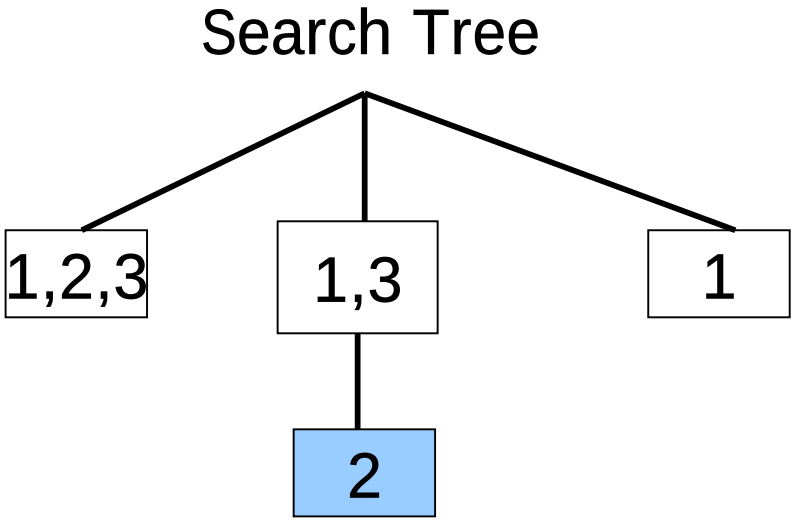
Score maximisation search tree

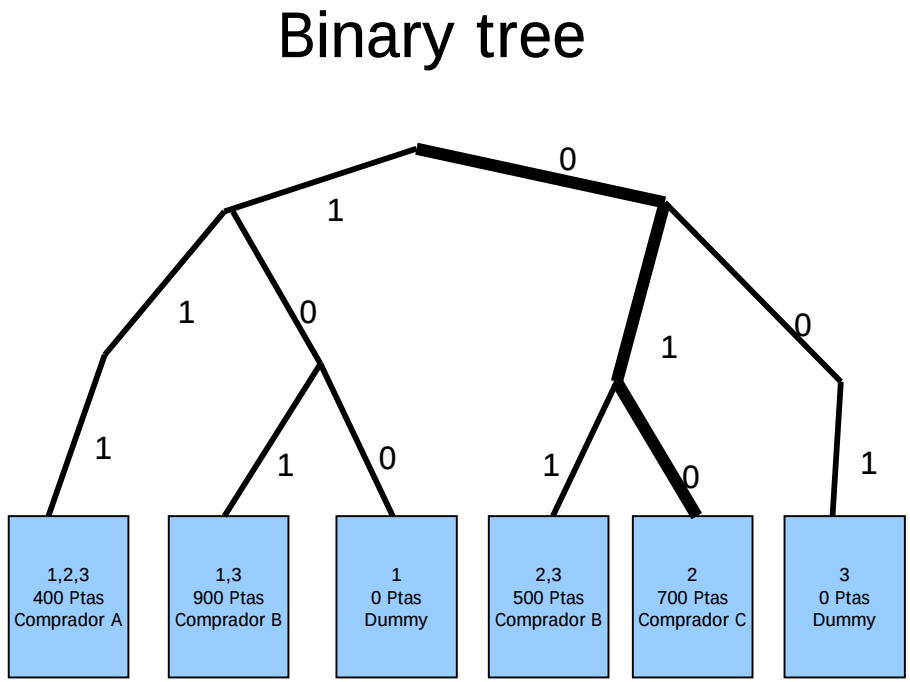




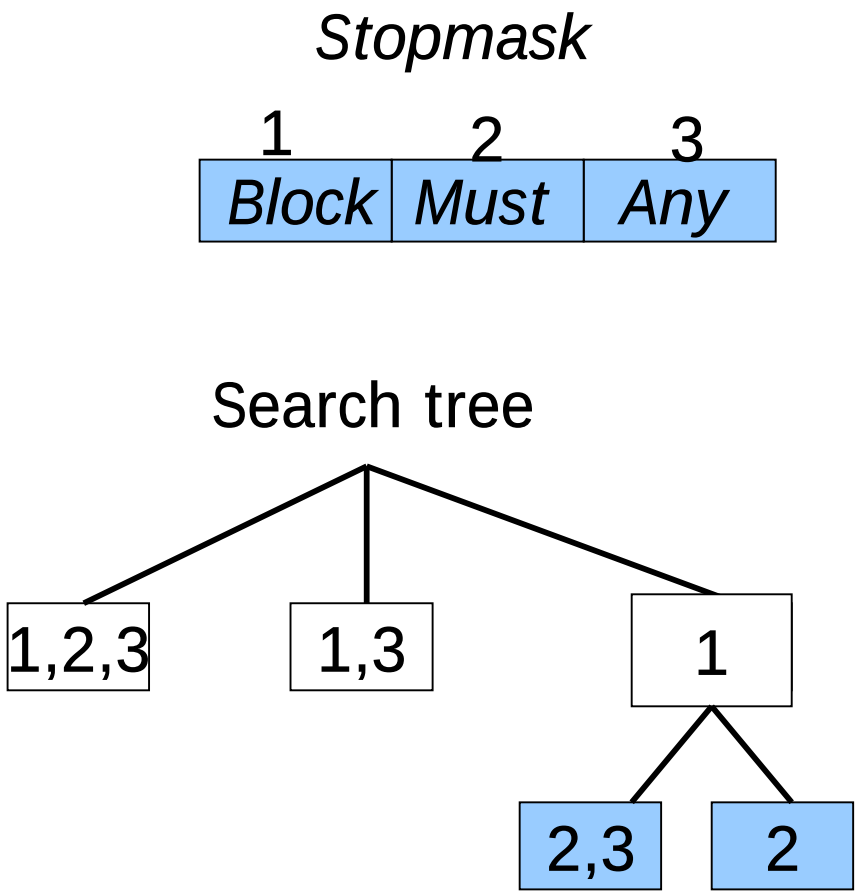
Score maximisation search tree

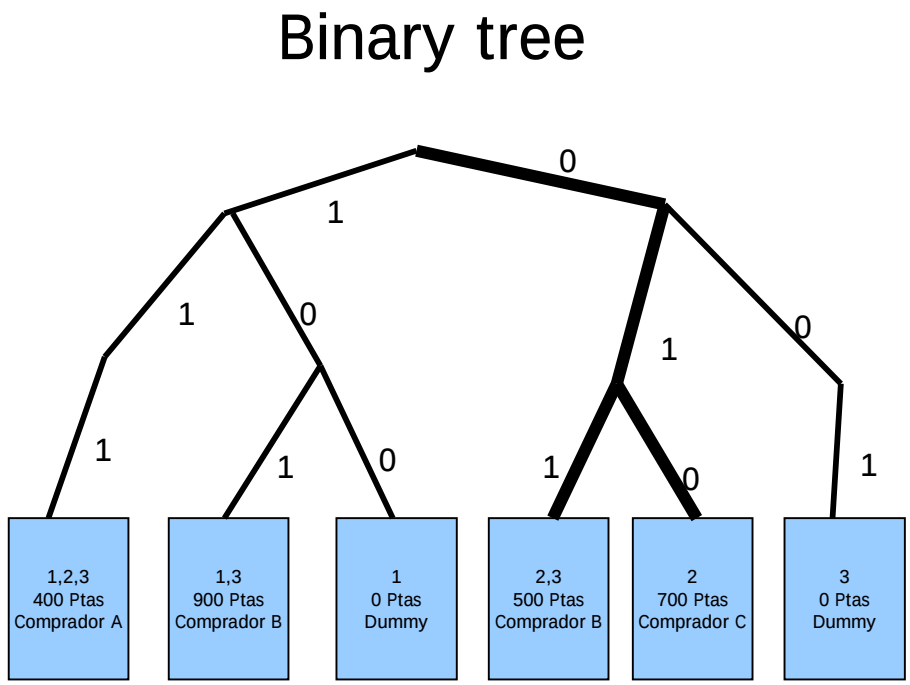






Score maximisation search tree





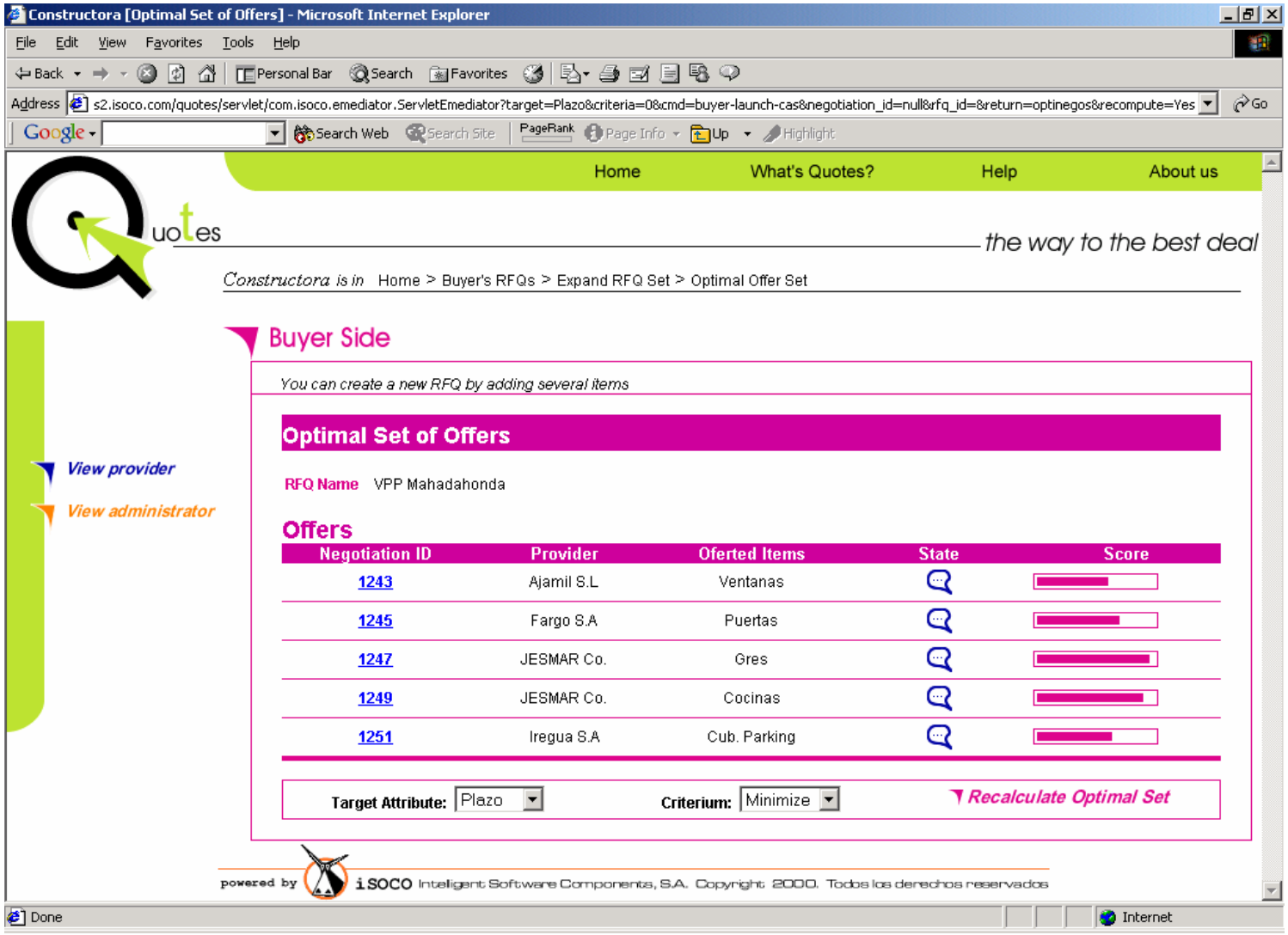
- Application of [Sandholm 99] algorithm.
- Pre-processing steps keep only the highest bid for a combination and remove provably noncompetitive bids.
- IDA* using heuristic function per node: **f = h+g**

$$h = \sum_{i \in unallocated\ items} c(i) \quad where \quad c(i) = \max_{S | i \in S} \frac{\bar{b}(s)}{|S|}$$

$$g = \sum_{i = unallocated\_items} b(s)$$

- Once the first solution is found, the algorithm converts to branch-and-bound with the same heuristic.

Example: delivery time minimisation



Desiderata. Buyer side

- **Negotiation over multiple, multi-attribute, multi-unit items**.
- High, **fuzzy expressiveness** to compose demands(e.g. quantity requested per item lies within some range).
- **Safety constraints**. Establish minimum/maximum percentage of units per item that can be allocated to a single provider.
- **Capacity constraints**. Allocated units cannot excede providers' capacities.
- **Intra-item constraints**. Capability of imposing constraints on the values a given item's attributes take on.
- **Inter-item constraints**. Capability of imposing relationship on different items' attributes.

Desiderata. Provider side

- **Multiple** bids/offers per provider
- Offers over **bundles** of items
- Types of offers over bundles
  - **XOR**. Exclusive offers that cannot be simultaneously accepted.
  - **AND**. Useful for providers whose pricing expressed as a combination of basis price and volumen-based price (e.g. ***Provider P***'s unit price is $2.5 and different discounts are applied depending on volume of required items: 1-10 units (2%), 10-99 (3%), 100-1000 (5%)).
- Offers expressed over quantity ranges in ***batch*** sizes (e.g. ***Provider P*** offers ***Buyer B*** from 100 to 200 3-inches screws in 25-unit *buckets*)
- **Homogeneous** offers that enforce buyers to select equal number of units per offer item.

- **Modelled** as a combinatorial problem defined as the optimisation(maximisation or minimisation) of:

$$\sum_{1\le j\le n} y_j \left[\sum_{1\le i\le m} w_i F_i(q_{ji}, f_{ji}(x_{ji}^1,\ldots,x_{ji}^{a_i}) \right]$$

  - y_j (binary) decision variable on j-th bid selection
  - F_1, , ... F_m set of scoring (cost) functions
  - q_{ji} number of units offered by j-th bid for i-th item
  - x_{ji}^k selected value for *k-th* attribute of i-*th* item of j-th bid
- **Realised** as a variation of MDKP (multi-dimensional knapsack problem).

CONSTRAINTS

- XOR bids must be satisfied
- AND bids must be satisfied
- Homogeneous combinatorial bids must be satisfied
- Aggregation of selected bids' quantities lies within requested ranges of units
- Units allocated to providers do not exceed their capacities
- Percentage of units allocated to a single provider does not exceed safety constraints

FORMALISATION

$$\sum_{1\le j\le n}\sum_{1\le j'\le n} y_j \cdot y_{j'} \cdot j(B_j \cdot B_{j'}) = 0$$

$$\forall 1 \le i, j \le n \;\; \alpha(B_i, B_j) \cdot (y_i - y_j) = 0$$

$$\forall B_j^i, B_j^k \in B_j \;\; h(B_j) \cdot y_j \cdot (B_j^i - B_j^k) = 0$$

$$\sum_{1\le j\le n} q_{ji} \in [m_i..M_i] \;\; \forall 1 \le i \le m$$

$$\forall p \in P, \forall 1 \le i \le m \;\; m_i \le \sum_{1\le j\le n} y_j \cdot r(p, B_j) \cdot q_{ji} \le M_i$$

$$\min_i(k) \le \sum_{i=1}^{m}\sum_{j=1}^{k} x_{ji} \le Max_i(k)$$

Constraints over item attribute values

§ How to enforce relationships between an attribute's values of a given item for all offers selected?

Let v_a be a variable referring to attribute ***a*** characterising some item ***I***. For each bid ***B*** including an offer for item I, the following constraint is in place:

$$v_a - y \cdot c <= (1 - y) \cdot \infty$$
$$v_a - y \cdot c >= (y - 1) \cdot \infty$$

v_a decision variable referring to the value of attribute ***a*** of item ***I***

y decision variable on the selection of bid ***B*** (y=1 means that B is selected)

c value that bid ***B*** assigns to attribute ***a*** of item ***I***

Constraints over separate items

§ How to enforce relationships between attribute values of separate items?

Let v_a be a variable referring to attribute ***a*** characterising some item ***I***. Let $v_{a'}$ be a variable referring to attribute ***a'*** characterising some item ***I'***. Then

- For each bid ***B*** including an offer for either item ***I*** or ***I'***, a constraint of the following type is in place:

$$(y-1)\cdot\infty <= v_a - y\cdot c <= (1-y)\cdot\infty$$
$$(y'-1)\cdot\infty <= v_{a'} - y'\cdot c' <= (1-y')\cdot\infty$$

- In order to relate v_a to the following constraint is added (where ***a,b,c,d*** are constant values)

$$a\cdot v_{a'} + c <= v_a <= b\cdot v_{a'} + d$$

Ibundler implementation

- **iBundler** implemented with the aid of C++ MIP and CSP libraries.
- Incorporated as a component into **Quotes**, iSOCO's strategic sourcing solution, providing:
  - assistance to buyers in one-to-many negotiations; and
  - automated winner-determination in reverse auctions.
- XML API enabling **iBundler** to work as a web service.

What is strategic sourcing?

Sourcing@isoco: Quotes

- Scoring (RFQs,offers,counteroffers)
- Winner determination
- Bidding rules

Summary

Future work

§ Neighborhood search.

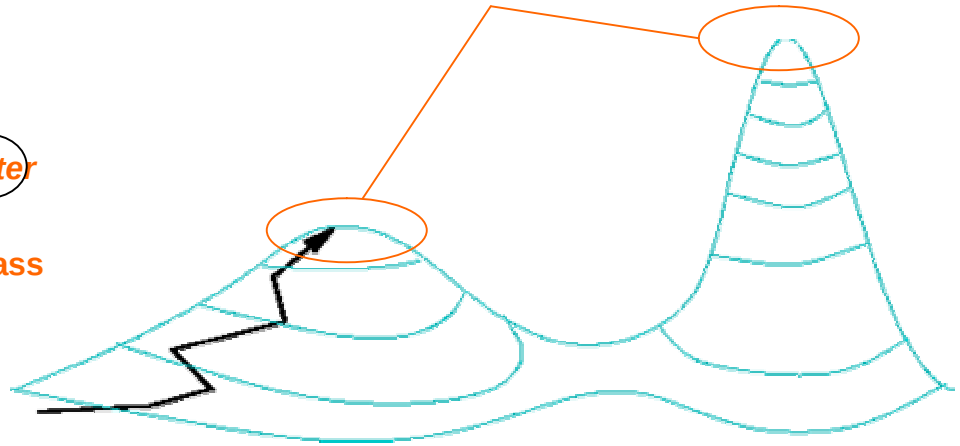
Neighborhood search is a random search technique that performs random movements in the solution space. In its basic form, it performs in a simple try-&-test.

1. **Construct an initial (incomplete) *Offer*.**
2. **While iterations<MAX_ITERATIONS**
   1) **Select an attribute randomly.**
   2) **Randomly change the value of the attribute.**
   3) **Apply the rule engine with the *provider's* bidding rules.**
   4) **Preserve the new offer if it is *better* than the current one**
3. **If the *Offer* obtained is *complete* and pass the buyer's reserve score.**

The offer gives value to all attributes.

Maximise both the buyer & provider scoring functions.

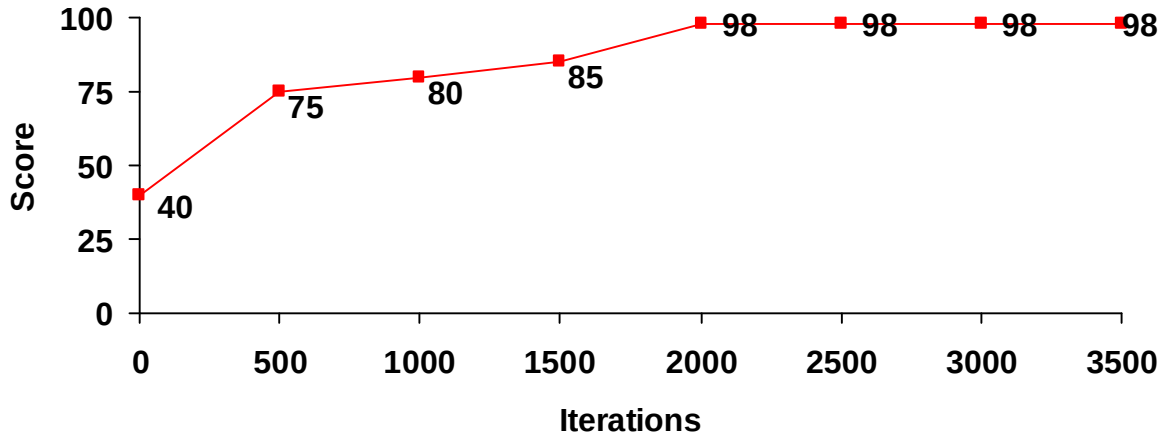
Problem!!! Local optima



Automatic generation of bids

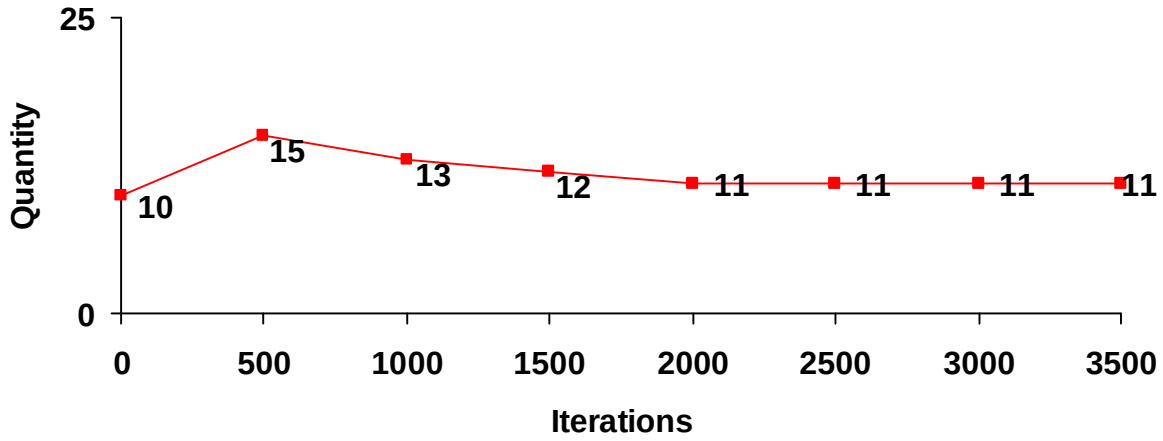
RFQ Buyer A

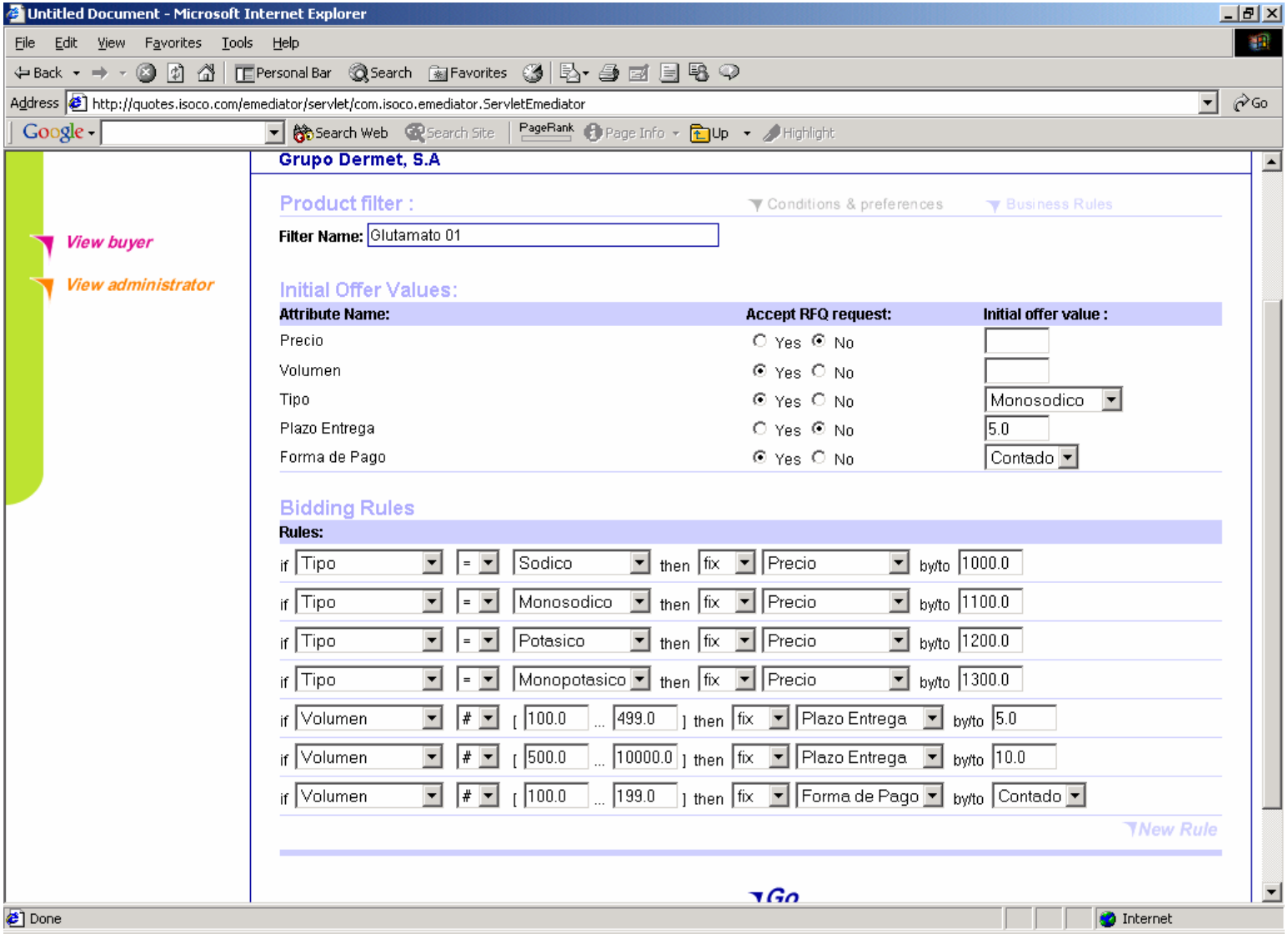
Price[8000..10000]
Quantity 10
Size 128 Mb
Speed 133 Mhz
Package Branded



Offer Provider B

Price 9360
Quantity 11
Size 128 Mb
Speed 133 Mhz
Package Branded

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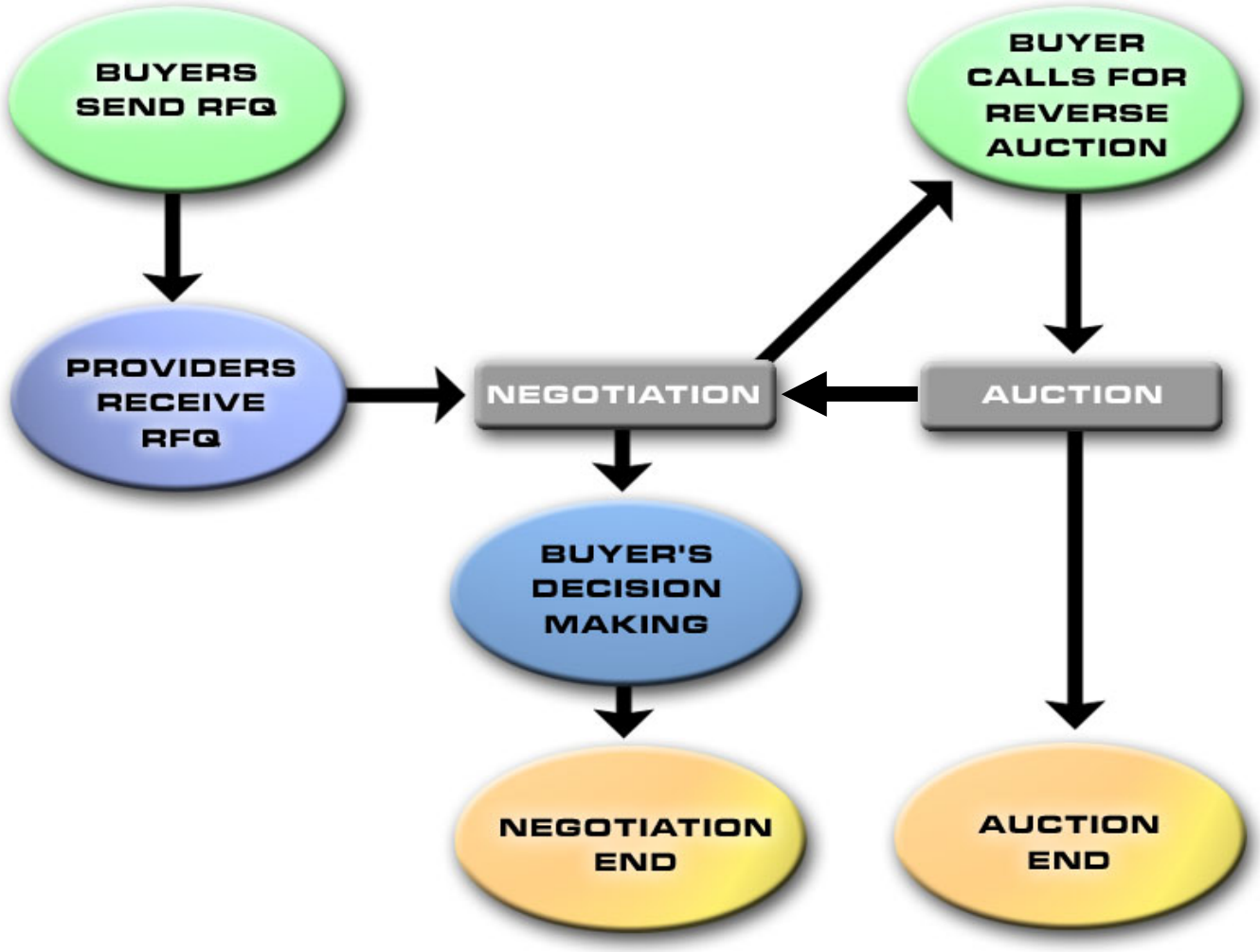
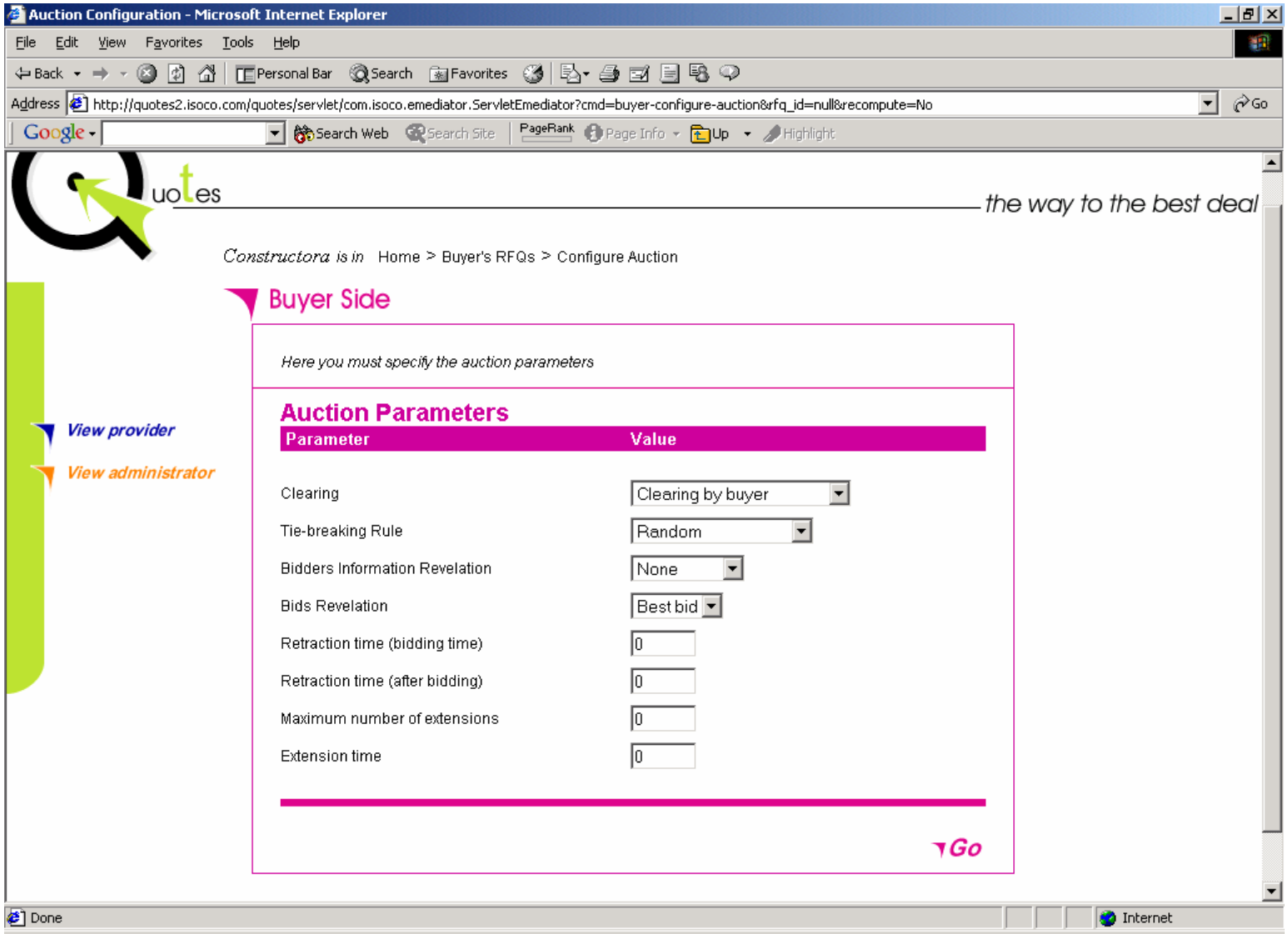
Grupo Dermet, S.A
View buyer
View administrator
Product filter :
Conditions & preferences
Business Rules
Filter Name: Glutamato 01
Initial Offer Values:
Attribute Name:
Accept RFQ request:
Initial offer value :
Precio Yes No
Volumen Yes No
Tipo Yes No Monosodico
Plazo Entrega Yes No 5.0
Forma de Pago Yes No Contado
Bidding Rules
Rules:
if Tipo = Sodico then fix Precio by/to 1000.0
if Tipo = Monosodico then fix Precio by/to 1100.0
if Tipo = Potasico then fix Precio by/to 1200.0
if Tipo = Monopotasico then fix Precio by/to 1300.0
if Volumen # [100.0 ... 499.0] then fix Plazo Entrega by/to 5.0
if Volumen # [500.0 ... 10000.0] then fix Plazo Entrega by/to 10.0
if Volumen # [100.0 ... 199.0] then fix Forma de Pago by/to Contado
New Rule
Go
Done
Internet

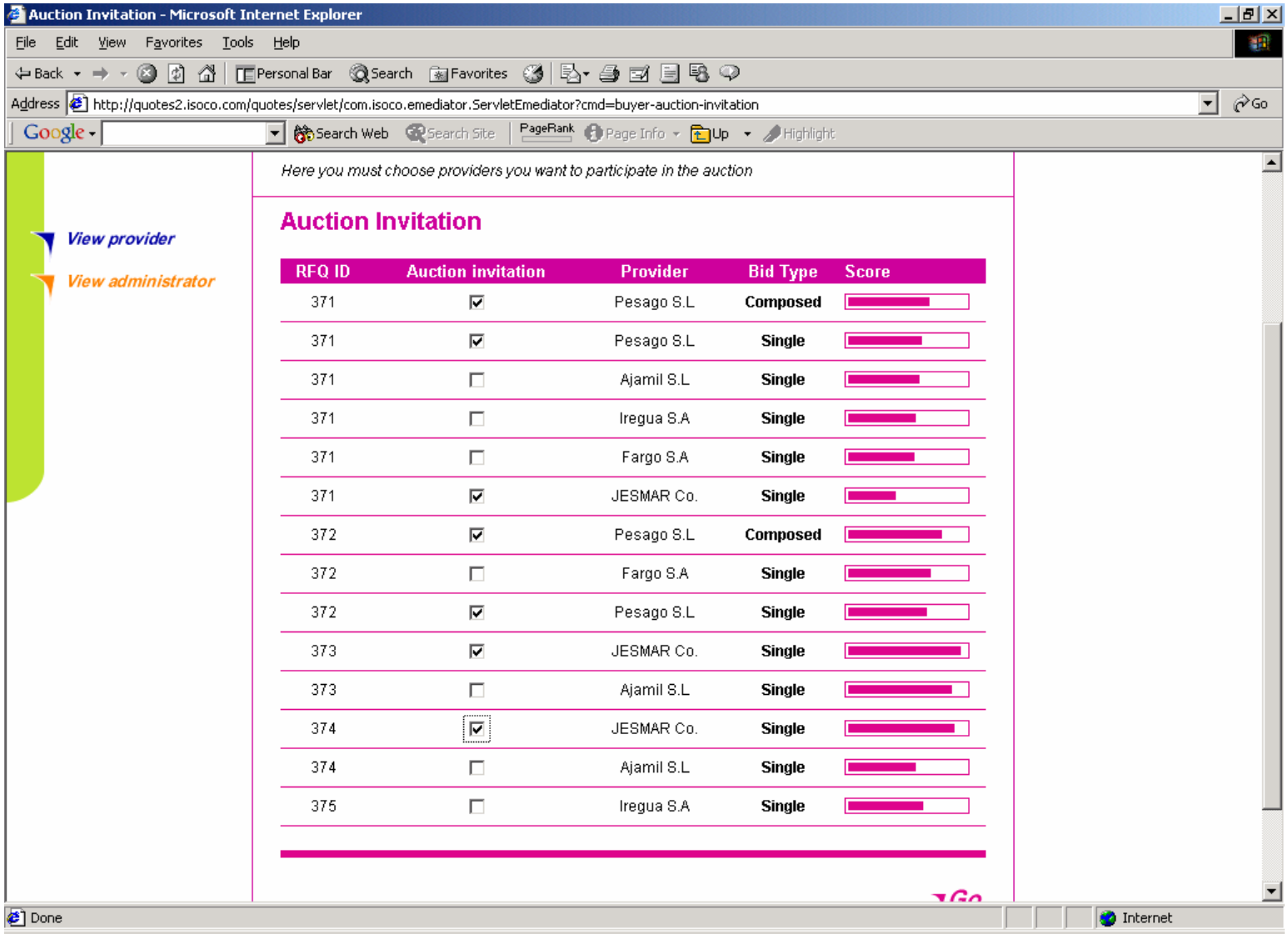


Quotes allows to select the negotiation mechanism (*pure* negotiation, reverse combinatorial auction, *negotiauction*) that best fits partners' business.

Auction parametrisation



Auction invitation



What is strategic sourcing?

Sourcing@isoco: Quotes

Summary

Future work

- **Integral solution** that supports the sourcing of goods and services
  - Indirect & direct.
  - Single or multiple items.
  - Multiple features.
- Select the negotiation mechanisms that best fits customers' business
  - **Structured negotiations** (preliminary offer, RFI, counter offer, firm offer progressions).
  - **Combinatorial reverse auctions.**
  - **Negotiauctions.**

§ Decision support

- Smart matching among buyers and providers.
- Scoring of RFQs, offers and counteroffers based on buyers preferences and providers profiles.
- Automated bidding (offers/counteroffers) through business rules.
- Winner determination employing optimisation techniques.

What is strategic sourcing?

Sourcing@isoco: Quotes

Summary

Future work

- Decision support to extract scoring function from buyers' preferences [Bichler 2001]
- Bidding automation for both buyers and providers [Faratin 2001]
- Incorporation and exploitation of schematic bids to improve winner determination and bidding capabilities in combinatorial negotiations and auctions:
  - Language to express schematic bids [Boutilier & Hoos 2000]
  - How to exploit algorithmically the language [Hoos & Boutilier 2000]

Thank you ... Any questions?