

Analytic Hierarchy Process (AHP) Tutorial

This tutorial presents a (fabricated) working example to reinforce an understanding of the AHP prioritization technique.

Situation Description:

We are analysts at *Blodger's Communications*. We are planning our next release. We have planned releases every four to six months. Due to this relatively short delivery time in which we must fit the planning; detailed requirements specification, analysis and design; programming; and thorough testing (including full regression testing), the scope of our release must be constrained. As well, *Blodger's* has fixed the systems budget which further necessitates the need to choose implementation items wisely.

The team responsible for product introduction and packaging services at *Blodger's* cannot agree on what to include in the release. This team consists of the Vice President (VP) of Sales and Marketing, the VP of Customer Care, the VP of Billing and Invoicing, the VP of Provisioning and Equipment Distribution, the VP of Finance, and the VP of Information Systems. At a meeting, one of our Senior Systems Analysts (a wise graduate from the University of Toronto who has been invited because of their great ability) proposes the application of the Analytical Hierarchy Process (AHP) to identify what will be included in the release and what will be excluded.

Here are **the items to be considered for the release**:

1. The Customer Care group has proposed that a **communication-tracking mechanism** be put in place. This would capture a record of all advice and quotations made to existing and potential customers. The purpose of this is to ensure that the store salespeople are aware of what the customers have been told in order to provide consistent service. As well, sales people are often befuddled by claims that customers make about phone conversations. This would help them to understand what the customer is talking about.
2. Billing and Invoicing want to **publish detailed bills online** and allow customer payment through credit card or pay-pal accounts. They want to **add a discount** for customers who choose to route their billing through the internet and further discount for those who pre-authorize bill payment.
3. Sales and Marketing, feeling the pressure of constant competition, brought about by the deregulation of the industry, want **more tools in their war-chest** to ensure that they can meet-and-beat the competition's offerings. Specifically, they want the ability to add new discounts on the fly using some kind of **generic system discounting tool**, rather than having to ask systems to *hard-code* changes to the system every time.
4. The Provisioning and Distribution team have been getting excited about the recent advancements in **RFID** (Radio Frequency Identification) tags and would like to incorporate their use in the **purchase, distribution, and sale of equipment**.

Before going further, the systems team goes back to their office to collaborate with their department on ROM (Rough Order of Magnitude) estimates for these enhancements. The cost and time required will obviously impact the delivery. In order to establish estimates, they consult with several groups including: Operations, to determine new storage and computing needs as well as future hardware maintenance costs; Database, to determine the impact to existing databases; Development, to get estimates for analysis, development and unit-testing; Test Team, to establish the testing requirements (some items may require more regression testing than others); and Maintenance, to determine ongoing support requirements.

They return with the following estimates:

1. **Communication-Tracking (CT)**: Here an assumption is made that the first go at this system will not be tightly coupled with the existing system, though one could navigate from an existing customer's record to communications with this customer. New hardware would be necessary to store the additional information, as well as separate processors. Testing would not need to be integrated with other systems functions, though, in later, more integrated releases of this feature, it would. The ROM for development and implementation (including training of all employees), is **\$500,000.00**.
2. **Online Bill and New Discounts (OB)**: These changes do not affect the way business is generally conducted - only how billing and collections occur. There are existing mechanisms to add prepaid billing discounts at little cost, however, a large overhead is anticipated in the serving up of the numerous bills, including enormous volumes of call details. The development of a secure billing site, including the new discounts is estimated at **\$900,000.00**.
3. **Generic Discounting Tool (GDT)**: This is a brand-new idea. It will affect billing and invoicing as well as initial provisioning and plan selection systems. Although no new equipment will be required, the systems processes will have to be revised to implement discounts generated by this tool. This implies extensive design, coding and testing. ROM for this tool is **\$600,000.00**.
4. **RFID**: The implementation of RFID does not affect most customer-facing applications. However, it would have to be integrated with the existing SAP systems. All SAP changes tend to be expensive and unnecessarily complex. The ROM for RFID is **\$650,000.00**.

Meanwhile, the VPs have decided what is important to them. Keep in mind that each player usually votes for the change which helps them most.

Analytic Hierarchy Process Tutorial (Solution)

Customer Care	normalize columns	Sum Rows	Divide by nbr of features																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>1</td><td>7</td><td>5</td><td>9</td></tr> <tr><td>OB</td><td>1/7</td><td>1</td><td>1/3</td><td>3</td></tr> <tr><td>GDT</td><td>1/5</td><td>3</td><td>1</td><td>5</td></tr> <tr><td>RFID</td><td>1/9</td><td>1/3</td><td>1/5</td><td>1</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	1	7	5	9	OB	1/7	1	1/3	3	GDT	1/5	3	1	5	RFID	1/9	1/3	1/5	1	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>0.69</td><td>0.62</td><td>0.77</td><td>0.50</td></tr> <tr><td>OB</td><td>0.10</td><td>0.09</td><td>0.05</td><td>0.17</td></tr> <tr><td>GDT</td><td>0.14</td><td>0.26</td><td>0.15</td><td>0.28</td></tr> <tr><td>RFID</td><td>0.08</td><td>0.03</td><td>0.03</td><td>0.06</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	0.69	0.62	0.77	0.50	OB	0.10	0.09	0.05	0.17	GDT	0.14	0.26	0.15	0.28	RFID	0.08	0.03	0.03	0.06	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>2.57</td></tr> <tr><td>0.40</td></tr> <tr><td>0.83</td></tr> <tr><td>0.19</td></tr> </tbody> </table>	2.57	0.40	0.83	0.19	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.64</td></tr> <tr><td>0.10</td></tr> <tr><td>0.21</td></tr> <tr><td>0.05</td></tr> </tbody> </table>	0.64	0.10	0.21	0.05
	CT	OB	GDT	RFID																																																												
CT	1	7	5	9																																																												
OB	1/7	1	1/3	3																																																												
GDT	1/5	3	1	5																																																												
RFID	1/9	1/3	1/5	1																																																												
	CT	OB	GDT	RFID																																																												
CT	0.69	0.62	0.77	0.50																																																												
OB	0.10	0.09	0.05	0.17																																																												
GDT	0.14	0.26	0.15	0.28																																																												
RFID	0.08	0.03	0.03	0.06																																																												
2.57																																																																
0.40																																																																
0.83																																																																
0.19																																																																
0.64																																																																
0.10																																																																
0.21																																																																
0.05																																																																

Billing and Invoicing	normalize columns	Sum Rows	Divide by nbr of features																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>1</td><td>1/7</td><td>1/3</td><td>6</td></tr> <tr><td>OB</td><td>7</td><td>1</td><td>3</td><td>9</td></tr> <tr><td>GDT</td><td>3</td><td>1/3</td><td>1</td><td>6</td></tr> <tr><td>RFID</td><td>1/5</td><td>1/9</td><td>1/6</td><td>1</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	1	1/7	1/3	6	OB	7	1	3	9	GDT	3	1/3	1	6	RFID	1/5	1/9	1/6	1	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>0.09</td><td>0.09</td><td>0.07</td><td>0.27</td></tr> <tr><td>OB</td><td>0.63</td><td>0.63</td><td>0.67</td><td>0.41</td></tr> <tr><td>GDT</td><td>0.27</td><td>0.21</td><td>0.22</td><td>0.27</td></tr> <tr><td>RFID</td><td>0.02</td><td>0.07</td><td>0.04</td><td>0.05</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	0.09	0.09	0.07	0.27	OB	0.63	0.63	0.67	0.41	GDT	0.27	0.21	0.22	0.27	RFID	0.02	0.07	0.04	0.05	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.53</td></tr> <tr><td>2.33</td></tr> <tr><td>0.97</td></tr> <tr><td>0.17</td></tr> </tbody> </table>	0.53	2.33	0.97	0.17	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.13</td></tr> <tr><td>0.58</td></tr> <tr><td>0.24</td></tr> <tr><td>0.04</td></tr> </tbody> </table>	0.13	0.58	0.24	0.04
	CT	OB	GDT	RFID																																																												
CT	1	1/7	1/3	6																																																												
OB	7	1	3	9																																																												
GDT	3	1/3	1	6																																																												
RFID	1/5	1/9	1/6	1																																																												
	CT	OB	GDT	RFID																																																												
CT	0.09	0.09	0.07	0.27																																																												
OB	0.63	0.63	0.67	0.41																																																												
GDT	0.27	0.21	0.22	0.27																																																												
RFID	0.02	0.07	0.04	0.05																																																												
0.53																																																																
2.33																																																																
0.97																																																																
0.17																																																																
0.13																																																																
0.58																																																																
0.24																																																																
0.04																																																																

Sales & Marketing	normalize columns	Sum Rows	Divide by nbr of features																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>1</td><td>3</td><td>1/3</td><td>5</td></tr> <tr><td>OB</td><td>1/3</td><td>1</td><td>1/5</td><td>3</td></tr> <tr><td>GDT</td><td>3</td><td>5</td><td>1</td><td>9</td></tr> <tr><td>RFID</td><td>1/5</td><td>1/3</td><td>1/9</td><td>1</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	1	3	1/3	5	OB	1/3	1	1/5	3	GDT	3	5	1	9	RFID	1/5	1/3	1/9	1	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>0.22</td><td>0.32</td><td>0.20</td><td>0.28</td></tr> <tr><td>OB</td><td>0.07</td><td>0.11</td><td>0.12</td><td>0.17</td></tr> <tr><td>GDT</td><td>0.66</td><td>0.54</td><td>0.61</td><td>0.50</td></tr> <tr><td>RFID</td><td>0.04</td><td>0.04</td><td>0.07</td><td>0.06</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	0.22	0.32	0.20	0.28	OB	0.07	0.11	0.12	0.17	GDT	0.66	0.54	0.61	0.50	RFID	0.04	0.04	0.07	0.06	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>1.02</td></tr> <tr><td>0.47</td></tr> <tr><td>2.31</td></tr> <tr><td>0.20</td></tr> </tbody> </table>	1.02	0.47	2.31	0.20	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.26</td></tr> <tr><td>0.12</td></tr> <tr><td>0.58</td></tr> <tr><td>0.05</td></tr> </tbody> </table>	0.26	0.12	0.58	0.05
	CT	OB	GDT	RFID																																																												
CT	1	3	1/3	5																																																												
OB	1/3	1	1/5	3																																																												
GDT	3	5	1	9																																																												
RFID	1/5	1/3	1/9	1																																																												
	CT	OB	GDT	RFID																																																												
CT	0.22	0.32	0.20	0.28																																																												
OB	0.07	0.11	0.12	0.17																																																												
GDT	0.66	0.54	0.61	0.50																																																												
RFID	0.04	0.04	0.07	0.06																																																												
1.02																																																																
0.47																																																																
2.31																																																																
0.20																																																																
0.26																																																																
0.12																																																																
0.58																																																																
0.05																																																																

Provisioning & Distribution	normalize columns	Sum Rows	Divide by nbr of features																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>1</td><td>3</td><td>5</td><td>1/9</td></tr> <tr><td>OB</td><td>1/3</td><td>1</td><td>3</td><td>1/7</td></tr> <tr><td>GDT</td><td>1/5</td><td>1/3</td><td>1</td><td>1/5</td></tr> <tr><td>RFID</td><td>9</td><td>7</td><td>5</td><td>1</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	1	3	5	1/9	OB	1/3	1	3	1/7	GDT	1/5	1/3	1	1/5	RFID	9	7	5	1	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>0.09</td><td>0.26</td><td>0.36</td><td>0.08</td></tr> <tr><td>OB</td><td>0.03</td><td>0.09</td><td>0.21</td><td>0.10</td></tr> <tr><td>GDT</td><td>0.02</td><td>0.03</td><td>0.07</td><td>0.14</td></tr> <tr><td>RFID</td><td>0.85</td><td>0.62</td><td>0.36</td><td>0.69</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	0.09	0.26	0.36	0.08	OB	0.03	0.09	0.21	0.10	GDT	0.02	0.03	0.07	0.14	RFID	0.85	0.62	0.36	0.69	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.79</td></tr> <tr><td>0.43</td></tr> <tr><td>0.26</td></tr> <tr><td>2.52</td></tr> </tbody> </table>	0.79	0.43	0.26	2.52	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.20</td></tr> <tr><td>0.11</td></tr> <tr><td>0.06</td></tr> <tr><td>0.63</td></tr> </tbody> </table>	0.20	0.11	0.06	0.63
	CT	OB	GDT	RFID																																																												
CT	1	3	5	1/9																																																												
OB	1/3	1	3	1/7																																																												
GDT	1/5	1/3	1	1/5																																																												
RFID	9	7	5	1																																																												
	CT	OB	GDT	RFID																																																												
CT	0.09	0.26	0.36	0.08																																																												
OB	0.03	0.09	0.21	0.10																																																												
GDT	0.02	0.03	0.07	0.14																																																												
RFID	0.85	0.62	0.36	0.69																																																												
0.79																																																																
0.43																																																																
0.26																																																																
2.52																																																																
0.20																																																																
0.11																																																																
0.06																																																																
0.63																																																																

Systems	normalize columns	Sum Rows	Divide by nbr of features																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>1</td><td>3</td><td>1/3</td><td>5</td></tr> <tr><td>OB</td><td>1/3</td><td>1</td><td>1/5</td><td>3</td></tr> <tr><td>GDT</td><td>3</td><td>5</td><td>1</td><td>9</td></tr> <tr><td>RFID</td><td>1/5</td><td>1/3</td><td>1/9</td><td>1</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	1	3	1/3	5	OB	1/3	1	1/5	3	GDT	3	5	1	9	RFID	1/5	1/3	1/9	1	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>0.22</td><td>0.32</td><td>0.20</td><td>0.28</td></tr> <tr><td>OB</td><td>0.07</td><td>0.11</td><td>0.12</td><td>0.17</td></tr> <tr><td>GDT</td><td>0.66</td><td>0.54</td><td>0.61</td><td>0.50</td></tr> <tr><td>RFID</td><td>0.04</td><td>0.04</td><td>0.07</td><td>0.06</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	0.22	0.32	0.20	0.28	OB	0.07	0.11	0.12	0.17	GDT	0.66	0.54	0.61	0.50	RFID	0.04	0.04	0.07	0.06	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>1.02</td></tr> <tr><td>0.47</td></tr> <tr><td>2.31</td></tr> <tr><td>0.20</td></tr> </tbody> </table>	1.02	0.47	2.31	0.20	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.26</td></tr> <tr><td>0.12</td></tr> <tr><td>0.58</td></tr> <tr><td>0.05</td></tr> </tbody> </table>	0.26	0.12	0.58	0.05
	CT	OB	GDT	RFID																																																												
CT	1	3	1/3	5																																																												
OB	1/3	1	1/5	3																																																												
GDT	3	5	1	9																																																												
RFID	1/5	1/3	1/9	1																																																												
	CT	OB	GDT	RFID																																																												
CT	0.22	0.32	0.20	0.28																																																												
OB	0.07	0.11	0.12	0.17																																																												
GDT	0.66	0.54	0.61	0.50																																																												
RFID	0.04	0.04	0.07	0.06																																																												
1.02																																																																
0.47																																																																
2.31																																																																
0.20																																																																
0.26																																																																
0.12																																																																
0.58																																																																
0.05																																																																

Finance	normalize columns	Sum Rows	Divide by nbr of features																																																													
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>1</td><td>3</td><td>1/3</td><td>5</td></tr> <tr><td>OB</td><td>1/3</td><td>1</td><td>1/5</td><td>3</td></tr> <tr><td>GDT</td><td>3</td><td>5</td><td>1</td><td>9</td></tr> <tr><td>RFID</td><td>1/5</td><td>1/3</td><td>1/9</td><td>1</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	1	3	1/3	5	OB	1/3	1	1/5	3	GDT	3	5	1	9	RFID	1/5	1/3	1/9	1	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr><th></th><th>CT</th><th>OB</th><th>GDT</th><th>RFID</th></tr> </thead> <tbody> <tr><td>CT</td><td>0.22</td><td>0.32</td><td>0.20</td><td>0.28</td></tr> <tr><td>OB</td><td>0.07</td><td>0.11</td><td>0.12</td><td>0.17</td></tr> <tr><td>GDT</td><td>0.66</td><td>0.54</td><td>0.61</td><td>0.50</td></tr> <tr><td>RFID</td><td>0.04</td><td>0.04</td><td>0.07</td><td>0.06</td></tr> </tbody> </table>		CT	OB	GDT	RFID	CT	0.22	0.32	0.20	0.28	OB	0.07	0.11	0.12	0.17	GDT	0.66	0.54	0.61	0.50	RFID	0.04	0.04	0.07	0.06	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>1.02</td></tr> <tr><td>0.47</td></tr> <tr><td>2.31</td></tr> <tr><td>0.20</td></tr> </tbody> </table>	1.02	0.47	2.31	0.20	⇒	<table border="1" style="width: 100%; border-collapse: collapse;"> <tbody> <tr><td>0.26</td></tr> <tr><td>0.12</td></tr> <tr><td>0.58</td></tr> <tr><td>0.05</td></tr> </tbody> </table>	0.26	0.12	0.58	0.05
	CT	OB	GDT	RFID																																																												
CT	1	3	1/3	5																																																												
OB	1/3	1	1/5	3																																																												
GDT	3	5	1	9																																																												
RFID	1/5	1/3	1/9	1																																																												
	CT	OB	GDT	RFID																																																												
CT	0.22	0.32	0.20	0.28																																																												
OB	0.07	0.11	0.12	0.17																																																												
GDT	0.66	0.54	0.61	0.50																																																												
RFID	0.04	0.04	0.07	0.06																																																												
1.02																																																																
0.47																																																																
2.31																																																																
0.20																																																																
0.26																																																																
0.12																																																																
0.58																																																																
0.05																																																																

Finally: Determine Total
add them up

CT	1.739
OB	1.144
GDT	2.245
RFID	0.872

Giving Sales and Marketing triple weight and Finance double weight
To better differentiate them.

CT	2.51
OB	1.50
GDT	3.97
RFID	1.02

Analytic Hierarchy Process Tutorial (Solution)

Create cost matrix (x / y)

	CT	OB	GDT	RFID
CT	1.00	0.56	0.83	0.77
OB	1.80	1.00	1.50	1.38
GDT	1.20	0.67	1.00	0.92
RFID	1.30	0.72	1.08	1.00

normalize columns

	CT	OB	GDT	RFID
CT	0.19	0.19	0.19	0.19
OB	0.34	0.34	0.34	0.34
GDT	0.23	0.23	0.23	0.23
RFID	0.25	0.25	0.25	0.25

Sum Rows Divide by #
features

0.75	0.19
1.36	0.34
0.91	0.23
0.98	0.25

Actually - that is not necessary - simply sum the costs and divide by the total costs for all features.

CT	\$500,000	0.19
OB	\$900,000	0.34
GDT	\$600,000	0.23
RFID	\$650,000	0.25
sum	\$2,650,000	

Now plot ROI Ratio (value / cost)

	value	cost
CT	2.51	0.19
OB	1.50	0.34
GDT	3.97	0.23
RFID	1.02	0.25

