

Data Analysis and Decision Making - II
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Lecture – 21

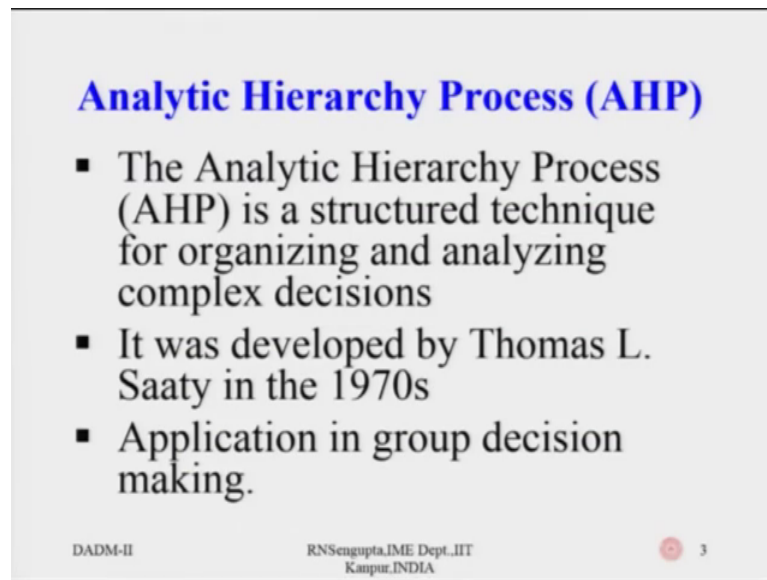
AHP

Welcome back my dear friends and students, a very good morning, good afternoon and good evening to all of you. And as you know this is the DADM - II which is Data Analysis and Decision Making - II course under NPTEL, MOOC series. And this total course duration is for 12 weeks which is for 30 hours, and each week we have a 5 lectures and each lecture is basically for half an hour and after each week we have one assignment.

Now, we have already completed 4 weeks that is 4 assignments and we are going to start the 5th week. And if you remember in the in the 4th week main part of the discussion was decision trees based on the fact that how we have been able to use the concept of and utility analysis. And before that we had covered the only simple formulation of DA, which I will come in order to solve that later on which I did mention. And I am again mentioning it and my name is Raghu Nandan Sengupta from the IME Department, IIT Kanpur in India.

So, today we will start the 5th week as you can see this is the 21st lecture, first lecture for the fifth week.

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Analytic Hierarchy Process (AHP)

- The Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions
- It was developed by Thomas L. Saaty in the 1970s
- Application in group decision making.

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So, today we will discuss the concept of analytical hierarchy process. Now, in analytical hierarchy process to give a very brief background whatever is written there I will read that explain that I will also give some something in a very general sense about the ideas of AHP.

AHP which is analytical hierarchy process is basically a so called subset of analytical network process where the relationship between different type of alternatives or different type of decisions are through a network analysis like a network, but what we know in network analysis in operation research, an network analysis in electrical engineering. Some relationship is given how one node affects the other node, what is the probability of effect, what is the flow and all these things are generally considered in general but not for ANP which is analytical network process.

And this method was developed by Saaty. So, Thomas L Saaty, in the 1970s. And this as the slide says the analytical hierarchy process is a structure technique for organizing and analysing complex decision where both subjective and objective decisions are to be taken. And where trying to rank the decisions considering both the subjective objective decisions may be a little bit difficult, where they are conflicting decisions, where the multi criteria concept has to be considered in such a way that all the different decisions have to be taken considering there are different decision makers where weightage has to be given on to the level of importance one should assign to the decision makers.

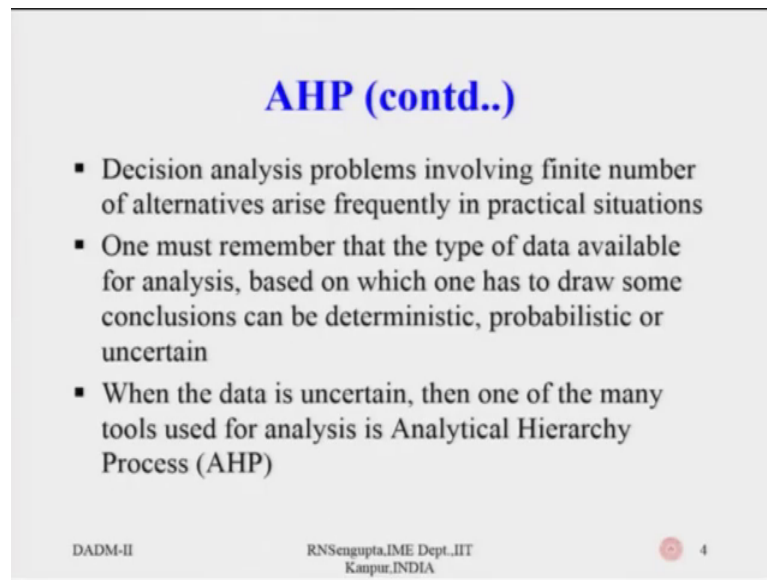
So, it was developed as I had already mentioned by Thomas L Saaty in the 1970s, and is an mean application is in group decision making. Group decision means say for example, there you want to hire one HR consultant in your company, and the general manager, the CEO, the managing director everybody wants to as a group conduct an interview. Obviously, each would have a different way of analysing the candidate, somebody would obviously, all the criterias can be academic qualification, past experience, the way he or she handles the interview, way he or she is able to answer the question, the competent knowledge the person has, the HR skill the person has.

But in spite of the fact even if there are points based on all these criterias each and every of the decision maker which I said the general manager, the CEO, the managing director they will basically have different ways of trying to analyze that candidates. So, here in this case you will try to utilize AHP in the most objective sense in order to arrive at the right decision.

Or say for example, you want to buy a car or example which will come later on. Or you want to basically buy a house, and if you remember I did mention about trying to buy a house where locality will be important, price of the house would be important, resale value of the house would be important, how the close the houses or the apartment is too near the shopping market, shopping mall would be important, how close the schools is important, how good that the transport system is in and around that apartment whether they are metro. Whether they are bus stops, where they are auto stops, whether they are taxi stops would be important, how safe that apartment would be in considering the locality would be important. So, all these things are considered.

And also maybe one other point which would be important is that resale value of that apartment. So, when you consider all these objective and subjective criterias, you want to basically take of the input from different decision makers such that you arrive at a consolidated score, such that it gives you much more a rational decision.

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AHP (contd..)

- Decision analysis problems involving finite number of alternatives arise frequently in practical situations
- One must remember that the type of data available for analysis, based on which one has to draw some conclusions can be deterministic, probabilistic or uncertain
- When the data is uncertain, then one of the many tools used for analysis is Analytical Hierarchy Process (AHP)

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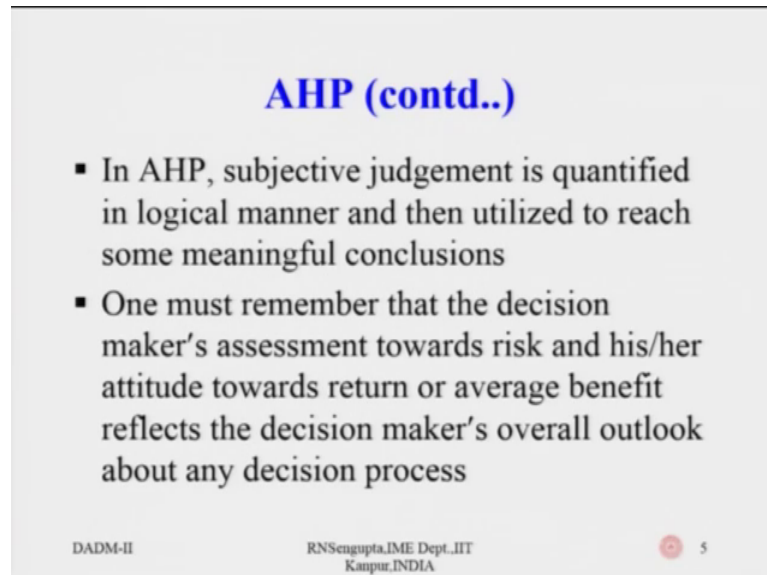
AHP which is a decision analysis problems, in decision problems involving finite number of alternatives; so, what are the alternatives? As I mentioned for buying the house. For the car can we say for example, the cost can be an important factor. The luggage space can be an important factor. The safety issue can be an important factor. The price of the car can be an important factor. The mileage of the car can be important factor. The resale value of the car can be important factor. The passenger space, amount of a space the passenger has number of passengers who can sit in that car is an important factor.

So, when you consider all these important factors the consider or the alternatives the I generally arise in any decision-making process. So, two very good examples which I just gave is for the car and the house.

One must remember, when you are trying to make a decision the type of the data available for these analysis based on which one wants to draw some conclusion can both be deterministic as well as probabilistic or they are uncertain. So, if they are deterministic we know for certain what are the values, what are the decision arms, in which way the decision flows. While if they are probabilistic you should basically have some probability or probability distribution, but we would not consider probability distribution we will only concentrate on the fact of probability values being assigned such that is easy for us to take a decision considering those probabilities. When the data

is uncertain as I just mentioned then one of the many tools which is actually utilized in this case is basically the analytical hierarchy process which we will discuss.

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AHP (contd..)

- In AHP, subjective judgement is quantified in logical manner and then utilized to reach some meaningful conclusions
- One must remember that the decision maker's assessment towards risk and his/her attitude towards return or average benefit reflects the decision maker's overall outlook about any decision process

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In AHP subjective judgment is quantified, some subject may be good bad, whether the houses are good locality, medium locality, bad locality considering safety. Or say for example, the price of the car is too high, it is affordable, it is definitely below much much below the overall budget which I have which is a cheap car. So, this may be subjective or criterias.

Other can be when you are selecting that candidate it may be that you are being biased because he or she is from the same institute very from where you have done your graduation or maybe the person is from that area where you belong.

So obviously, those points are not rational, but these type of subjective criteria, the subjective decision, points do generally come or maybe the person has a very good experience for a good company or maybe the person is very good in talking. So, these basically points which are considered in a subjective way should definitely be considered using the points such that you arrive at a much more logical answer.

So, let me read it again. In AHP subjective judgment is quantified in logical manner and then utilized to reach at some meaningful conclusion. The second point says one must remember that the decision makers assessment towards risk and his or her attitude

towards return or average benefit. I am basically considering they are two conflicting points we should be mentioned, one is basically the amount of positive benefit which you will get and another is basically the amount of so called negative benefit which you will basically go out from your pocket.

If you remember the decision tree analysis what we have? You had to basically build a factory and then you basically got some returns at an interval of 1 year for 20 years. So, in that probability was 30 million per year for the coming 20 years when if the demand was high. On other case was basically you got a return of 20 million per year for the coming 20 years if the demand is low. And obviously, you you had a sun cost where the money was basically utilized to build up the factory or do some pilot runs or do some marketing so on and so forth.

So, we will consider both the factors which is basically the risk and the returns in such a way that they give us a much rational decision in order to arrive at what is the best decision considering different type of alternatives which you have.

So, it will, so in this process we get the decision makers attitude to a risk or average benefit and it reflects the decision makers overall outlook about any decision process. So, that they need not be rational, but it gives us a good picture that how the decision maker analyse any alternative considering different type of criteria such that he or she is able to arrive at a decision which gives him or her the best benefit. So, we will basically collate all these decisions and try to arrive at a answer.

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AHP (contd..)

- Consider Ram has received the final calls from IIMA, IIMB and IIMC. His main criterion based on which he will take the decision is
 - ❖ 1. Academic reputation
 - ❖ 2. Placement potential
- For his academic reputation is two (2) more important than placement potential. Thus placement potential is $\frac{1}{3}$, while academic reputation is $\frac{2}{3}$

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So, let us consider through a very simple example we will basically increase the level of involvement in the problems accordingly. So, consider Ram has received the final calls from 3 institutes which is IIM Ahmedabad, IIM Bangalore, IIM Ranchi, Calcutta. So, there are a b c. Oh, by the way, in the problem which you are discussing the actual theoretical concept we will come later on, but I am just giving trying to give you a view that how logically you can solve this problem.

Ram's main criteria to based on which he will take the decision there are two. So, it may be more than two also it can be less than two also. So, for him the decision criterias are or the importance are based on academic reputation, how good the teachers are, how rigorous the course is, whether different type of new courses in finance in marketing in operation research are done.

So, all these things are considered as a part and parcel of academic reputation. And academia reputation through to can be say for example, how frequently the examinations are held, what is the overall feedback from the industry about the academic rigor of the course, how frequently people go abroad for do high for doing higher studies. So, all these things may be considered by Ram in order to arrive as at some level of score for the academic reputation.

The other criteria based on which Ram takes a decision for the alternatives is basically the placement potential. Placement potential can be what type of different companies

come, what is the medium salary, what is the average salary, what is the maximum salary, what different type of companies in finance come, what different type of companies in marketing come. So, all these things are considered. It may be also that how many students are recruited by those companies in each and every field. So, these information both academic and placement one are considered by Ram to arrive at the decision.

Now, let us consider and here I will basically explain a little bit more in depth. So, it mentions which is the second bullet point. For his, that is Ram's academic reputation is two or twice more important than placement. Thus placement potential is given a weight of one-third and while academic reputation is given a weight of two-third. Which means that if I place academic reputation at twice the level of placement, so out of the 3 total score of 3 points or it can be 6 points or it can be 9 points whatever it is I am basically considering that it can be proportionally divided.

There Ram would basically assign 33 percent 33.33 percent of the weightages on placement and the rest which is 66.67 percentage of the weights would be going to academic reputation. So, whatever the weights you place they would be divided accordingly to the ratio of one-third is to two-third for the case of placement potential with respect to academic potential for Ram.

Now, here the question comes is you just saw arbitrarily hypothetical values of one-third and two-third. Now, the question may come from your fact, so did I assume hypothetically? The answer is yes, but the scores of one-third and two-third or 1 is 2 the score which is being assigned to placement with respect to academic potential is being given by Ram who is the decision maker. If I am the decision maker in place of Ram then my overall score which is which I assign to placement potential and academic potential or academic rigor would definitely may not be 1 is to 2. Say for example, it can be 1 is to 4 or it can be 2 is to 1.

So, the points which are assigned depends on the decision maker based on which you will basically collate the data in order to arrive the answer. So, if you remember I did mention that it sometimes become subjective, but that subjectivity comes from the point of view of the decision maker who is assigning those points with respect to the different type of decisions or the alternatives which are there.

Now, if you remember I did mention that academic and my potential or reputation and placement potential are the only two criterias it can or it can be more than 2. So, it can be placement potential, it can be academic rigor, it can be say for example, how the place is that, what is the infrastructure, how good or bad the infrastructure, is it may be also be that whether if there are relatives for Ram in that place he would be basically more be more inclined to visit that place because when it comes to during the holidays he would be in a much better position to visit his relatives which he thinks is where also important and a part and parcel of life. So, all these subjective things would definitely be taken into consideration. But for the time being I am only considering academic reputation and placement potential.

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AHP (contd..)

▪ Thus Ram ranks this as

Criterion	Percent weight estimates		
	IIMA	IIMB	IIMC
Academic reputation	0.40 ✓	0.25	0.35
Placement potential	0.30	0.40	0.30

❖ IIMA: $(0.30 \times 1/3 + 0.40 \times 2/3)$
❖ IIMB: $(0.40 \times 1/3 + 0.25 \times 2/3)$
❖ IIMC: $(0.30 \times 1/3 + 0.35 \times 2/3)$

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Thus, Ram's ranking based on Ram's own set of scores are like this. So, when Ram considers academic academic reputation, he is basically giving a scores accordingly; again, it is subjective. He places 40 percent of the weight on IME when only academic reputation.

Now, initially the ranking was done based on two different criteria, criteria based on which Ram is going to take a decision. Now, you are basically trying to pick up each and every criteria and give points based on the decision alternatives or the which is the alternatives. What are the alternatives? One is IIM Ahmedabad, one is IIM Bangalore

and one is IIM Calcutta. So, Ram is placing academic reputation for IIM Ahmedabad the highest, for IIM Calcutta the second level and from IIM Bangalore the third level.

The points which he wants to assign if you consider the overall score of 100 or 1, whatever it is I am just basically trying to normalize it. So, initially it may not be normal, but I will try to normalize it. So, the normalized scores which are happening is 40 percent for IIM Ahmedabad for academic reputation, 25 percent for IIM Bangalore for academic reputation, and 35 percent for IIM Calcutta for academic reputation. Now, let us come to the placement potential. If you remember placement potential with respect to academic reputation was in the ratio of 1 is 1 by 3 is to 2 by 3. So, it was twice for academic reputation.

So, now for the placement potential consider the scenario for Ram. Again, when you normalize again a very hypothetical example, but check the values it will give you some information. He places 30 percent waitage on IIM Ahmedabad on his total score for placement potential, 40 percent where which means that he is trying to basically give the highest score for IIM Bangalore which is as 40 percent.

And he is also given a score of 30 percent from IIM Calcutta. So, which means for academic reputation the scoring in the ranking system was IIM Ahmedabad first, IIM Calcutta second, IIM Bangalore third while in the placement potential it was basically IIM Bangalore first and both IIM Ahmedabad, then IIM Calcutta at the same standing.

So, if I consider the scores assigned to IIM Ahmedabad, IIM Bangalore, IIM Calcutta based on these two points for Ram they would be the multiplicative factors. And then sum it up for the its falling points, what is the amount of points which you are putting for academic reputation with respect to placement potential, and each point would be multiplied by the fact of the score which you are trying to put for IIM Ahmedabad, IIM Calcutta and IIM Bangalore based on each and every individual criteria which you have.

So, it can be expanded. Like I will try to draw it here so maybe the decision is here and for each decisions you have basically a I am putting the alphabet A for Ahmedabad, B for Bangalore and C for Calcutta and academic reputation AC placement potential, same thing AC and PI for B, AC and PI for C.

Now, here you saw or if you and look at this diagram this is the first hierarchy, this is the third, second hierarchy. Now, this hierarchies can go on to tertiary level and below that which means that the overall level of importance which you are going to give to each and every criterion alternatives would basically depend what are the different hierarchies which you have. And basically, we go from the bottom part, keep multiplying the factors till you basically reach the main decision point where you want to basically make a decision.

And each of the paths; paths being I will use a different a colour. So, maybe this is path 1, consider this is path 2, consider this is path 3, consider this is path 4. And similarly you will basically have all different paths such that the sum of the product of these probabilities of the points would give you the scores, and you will rank them from the maximum of the minimum and take the one which basically suits your criterion.

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AHP (contd..)

- Now consider Ram's brother Shyam, also has got calls from the same three institutes and both want to be in the same place, so that their parents can reduce their overall cost of expenditure

Decision: Select IIM

Hierarchy # 1: Placement potential Academic Reputation

$\frac{1}{4}$ $\frac{3}{4}$

Placement potential

Alternatives:	IIMA	IIMB	IIMC
	0.25	0.25	0.50

Academic Reputation

Alternatives:	IIMA	IIMB	IIMC
	0.35	0.35	0.30

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Now, consider now let us make the problem more interesting. So, till now you had only Ram now consider the fact that Ram has (Refer Time: 20:53) brother. So, Ram got say for example, got the offers of ABC on 25th of January as considered hypothetical. So, he is very happy, he makes a decision and you saw that that how he had made the decision with respect to this academic potential, placement reputation, with respect to each he had ranked ABC.

Now, after 4 days Shyam his brother gets a call. So obviously, Shyam is also happy. So, Shyam get got calls for the MBA program from the same 3 institute. It need not be, but I am basically considering it in a very simplistic measure. It could have been Lucknow or Indore or say for example, (Refer Time: 21:44) whatever it is. It can be Indian, abroad whatever you will try to basically consider those points accordingly. But for the time being it is again ABC for Shyam.

Now, the overall weightages of the criterias or weightages of the different type of points based on which or the what I will say the characteristics based on based on which Shyam will take the decision are, again placement potential and academic reputation. But for Shyam the academic reputation and placement potential are not no longer in the ratio of 2 is to 3 is to 1 is to 3, because now Shyam thinks academic reputation is more important for him. Hence, the scores which he is putting and this is against subjective based on shams own decision. Ram has nothing to do here because Ram decision was not being affected by Shyam and similarly shams decision is not being affected by Ram. So, I will just highlight it.

So, if you see the weightages are one-fourth and three-fourth that means, the weightages of academic reputation is thrice that of placement potential, in the initial case it was twice. Now, when I again consider and ask the question to Shyam for him or her the alternatives are say for example, for placement potential we shall highlight here. For him IIM Calcutta is the highest, hence he gives a weight of 50 percent, out of the total normalized score of 1 or if it is 100 it will be 50 and he places Ahmedabad and Bangalore at the same level of 25 or out of 100.

Now, you may be thinking why did he do so, like why did he place a score of 50 percent on Calcutta. May be say for example, Shyam is more finance oriented more operation research oriented, where the job market for finance and operation research would be more much better in Calcutta with respect that is his perception, with respect to Ahmedabad and Bangalore. Hence, he puts a score of 25, 25 and 50 for A, B and C respectively.

Now, come to academic reputation. For him the academic reputation from IIM Ahmedabad then IIM Bangalore are same and that of Calcutta is one notch lower. So,

hence he basically places a score of 35, 35 to Ahmedabad and Bangalore and the 30 point for the score for academic reputation for Calcutta and which is being done by Shyam.

Now, you may think well if Shyam is basically thinking that the academic reputation from IIM Calcutta is higher for finance and operations obviously, his score for the academic rigor for IIM Calcutta on based on these points should be much higher, which is true, technically should be. But when people take decisions it would may not be. We will consider a rationality is there and we will try to overcome that irrational decision by considering the consistency index and the ratios. We will come to that later on. So, if there are conflicting points which is being mentioned by a one person so obviously, we will try to take care of that and what is conflicting I will come to that later on.

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AHP (contd..)

- IIMA: $(0.25 \times 1/4 + 0.35 \times 3/4)$
- IIMB: $(0.25 \times 1/4 + 0.35 \times 3/4)$
- IIMC: $(0.50 \times 1/4 + 0.30 \times 3/4)$

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So, when you consider shams score it is basically, again the multiplicative factor of the points which he places from for IIM Ahmedabad, IIM Bangalore, IIM Calcutta and the scores which here basically given with respect to the academic reputation and placement potential of 3, 3 by 4 is to 1 by 4 would also be considered. So, these are the scores which are given.

0.25 into one-fourth, one-fourth is the ratio of placement with respect to academic. And for Ahmedabad it he had basically given a score which was the same ranking IIM Bangalore, so it was 25 into one-fourth. And 35 we had given the highest score for academic rigor, so its 0.35 or 35 into 3 by 4. Similarly, for IIM Bangalore this is 0.25 into

one-fourth plus 0.35 into three-fourth and finally, he for Calcutta is 0.5 because he had given the highest point for placement potential is 0.5 into one-fourth plus 0.3 which is for the academic reputation in to three-fourth.

Now, say for example, let us make the problem more interesting. I have not added that, but let me analyse and tell you the background. Now, say for example, now after the letter came for Ram and then for Shyam say for example, the parents are very Ram's and Shyam's parents when they are elated, but let us consider the actual practical situation they are going to face; Ram.

So, if you considered individually Ram, Ram has one decision whatever the alternative is it can be A or B or C, I am not going to in the details I am basically mentioning the more qualitative feel of that. It can be, say for example, here he has chosen Ahmedabad and say for example, Shyam has chosen Calcutta. So, individually they are very happy, but let us consider what is the overall objective decision which the family has to take as a group. Now, for Ram and Shyam the overall points are overall importance is their parents will give both to Ram and Shyam would be of the same level, maybe it is so hence when Ram and Shyam's parents gives scores to the decisions; decisions are basically the sons would basically be 50 percent and 50 percent.

Next point can be say for example, if they think their one of their relative is there in Bangalore. So obviously, both the parent should definitely be in Bangalore. But other point can be see, for example, the cost of Bangalore is very high, but Calcutta cost is low. So obviously, the cost factor, the relative factor, the importance they want to place on this sons scale career all these points would be considered in a very rational line such that both Ram as well as Shyam along with the decision which the parents take would be considered to arrive at a cumulative score. Such that, the best alternative which is taken by each may not be best for them, but overall it will be best one considering the points which have been put by them individually when they are take going to take that subjective and objective criterias into consideration are very rational.

So, with this I will end the 21st class and continue more about the discussion on the AHP in the 22nd and the 23rd class accordingly. Have a nice day and.

Thank you very much.