Introduction to Geographic Information Systems

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Lecture - 02
Different components of GIS

Hello everyone, this is a second lecture, which is in continuation of a previous lecture in which I have introduced an overview of what is GIS. As you know each and every system having different components, so GIS if you take say example of a pencil then pencil having two major components; one is your graphite another one is wood.

Similarly, in GIS we are having different components one. More important thing, which I would like to bring in the previous lecture I have touched little bit about coordinate geometry. The basis of GIS is completely mathematics, but in this course, we are not go into the details of mathematics, but how mathematics in background is working for us time to time I would we definitely bring in those points. Like a study or in previous lecture, we have discussed about coordinate geometry, the mathematics on interpolation the mathematics on set theory, mathematics on different aspects of a polynomial equation other things are all used in GIS. So, everything in the background is a based on mathematics, but on front end we do not see those things except the user interface.

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So, let us say go into the deep more starting with different components of GIS. GIS is if you see different literature or books or on web pages, you would find people will describe maybe five components, six components and so and so forth. But I feel that a we can very well segmented, GIS into five major components, and these components.

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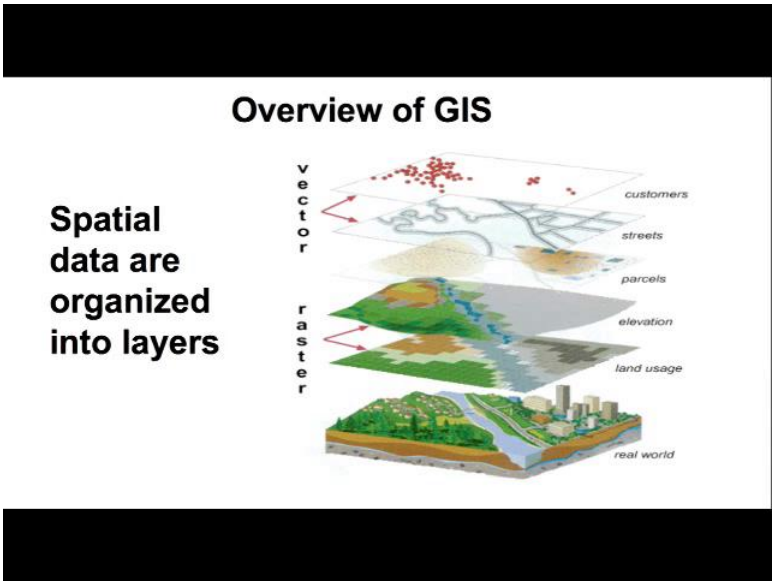

As you know that in the previous lecture also we have discussed this figure that because the real world we are segmenting or discretizing into different layers; in order to do that, so that we can towards the analysis or modeling or prediction we need to have different components. So, the first component because if you recall the definition of GIS, it is mentioned that it is a computer based information system. So, it has to have a software as well as hardware.

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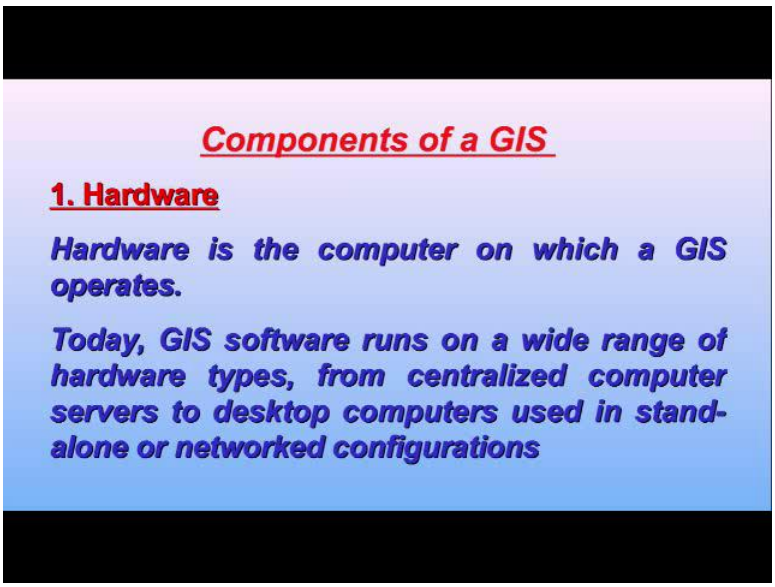

So, you know that a hardware is a computer on which GIS operates. Now, this is very interesting; nowadays, it is not necessary that you should have super computers, mainframe computers for GIS analysis; even on smart mobiles a basic GIS can function. So, GIS say for the hardware wide range of hardware is available on which GIS can run. There are software which are high end software of sort of a big software which require workstation and the same software a stripped version of the same software can run on your palm top or laptop or even on your smart mobiles, having say window operating system or android as well.

So, hardware nowadays GIS is available on all kinds of platforms. And keep the example of a previous lecture about like a Google map or Google Earth. Google map is also available on variety of platforms. So, you need to have hardware. And as you know that

the hardware runs on wide range of computers and from centralized computers, computers on servers, desktop computers standalone network configuration all kinds of combinations are available now. So, hardware is one of the most essential as per the definition of GIS the first component.

The next one comes, the software this is another very important component because without having software you cannot have real GIS operations. Here I would like to give you one analogy, which is very interesting and the analogy is that GIS is something like a carpenter's toolbox. Someone may surprise with this analogy, but let me explain that you go in the market and you can buy a carpenter's toolbox, but you will realize very soon that the carpenter's toolbox having different tools for example, it is might be having hammer, saw or a you know maybe drilling machine and so and so forth. But the carpenter's toolbox will not have design; will not have the raw material.

So, this is very important the similarly in GIS though you may get hardware you may install a GIS software, but if you do not have the data which is our next component then it is useless. And if you do not have designs like for carpenter if he does not know how to prepare a chair then you the carpenter's tool box is useless for him even if he is having wood that means, the material and in our GIS parallel we can call as data. So, all these five are most essential, and have to be there together then only a GIS can function.

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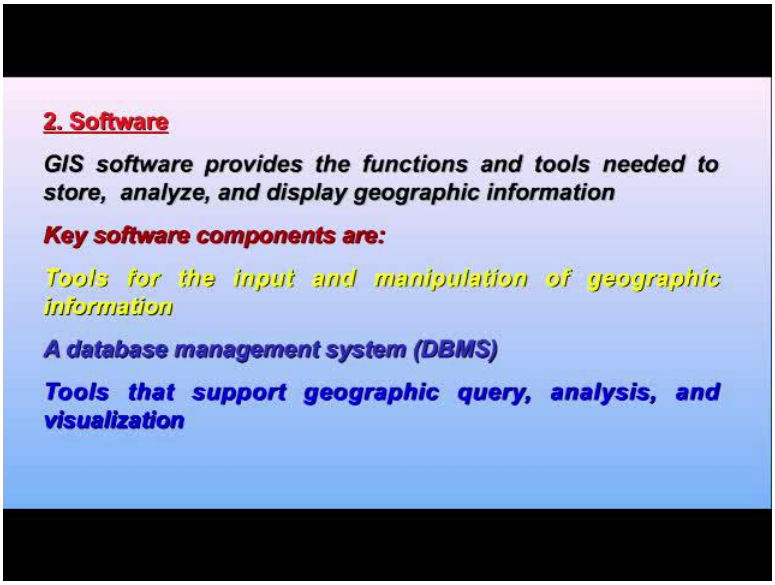

So, the second component that you need the software to run your GIS operations, this provides functions and tools needed to store and analyze, display geographical information that is the main purpose of GIS software. Now, similarly like GIS software are available again on wide range of platforms and wide range of operating system. As time is passing when GIS was invented by Rogers Thomason, at that time it was on (Refer Time: 06:42) you have to they operating system where all together different may be unique or some other operating system. Later on most of the now most popular GIS softwares are now on window machines which are having very powerful set of tools and most of the task which you can think in GIS can be performed on a these windows machines maybe running on workstation or even laptop.

So, the software is basically the purpose of these softwares - GIS softwares as a displayed here to store, analyze and display geographic information. Remember all the time everything is related with coordinates, geographic coordinates location is specific coordinates. So, everything which we are handling which is the unique thing in GIS which is not common in CAD machines or CAD CAM softwares or other technologies, but only GIS provides that functionality to use geographic coordinates. The key software components within the software the components which we look in GIS software like for input of the data we would like to bring the data because by definition data might be

coming from variety of sources. And therefore, your GIS software should be capable of receiving data from variety of sources. Here variety of sources as mentioned earlier that maybe the field data, maybe the remote sensing data, maybe the data coming from some excel sheet, may from already existing data, which is or maybe analog data, which has to be converted onto in to GIS platform.

So, the input capabilities, good GIS software should have very good input capabilities; some time you even have to key in the data within the GIS database. Now also it should allow us to manipulate the geographic information; manipulation does not mean that we are corrupting the data. Manipulation means changing from one format to another for example, like from analog to digital, digital - one format digital to another format like in a images be to sometime we get images in tiff format we convert them to maybe jpg format or img format depending on the requirements of individuals softwares. And then your another key component within the software is the database. So, good GIS software should support a very good database management system.

Third is the tools for support geographic query, because ultimate aim after developing the database bring the data inside the data, organizing the data in a efficient manner then comes the query, analysis and visualization output which you are looking. So, your GIS software should support all these things. And the last in this one is that it should have nowadays it is required, in earlier versions everything was through command mode. So, everything has to be typed now all it is through windows or a GUI interface. So, you are having a easy access to these tools very easily.

One very important question comes here that some suppose somebody is looking that a he will start working on GIS, because the project or the problem on which he is working he feels that he can use GIS to solve those issues. Now, the next question will come in this mind that which software because in previous lecture I have mentioned there are hundreds of softwares available. So, which software? Now, I can give you some criteria on which one should judge and then buy or arrange those softwares. The first criteria in my opinion is that the software should be modular fashion that means, today you are having certain amount of funds you buy the software. Now, tomorrow you are having more requirements, you are having again some funds available, so you buy another some

add-on or modules which can very well with your existing basic installation of GIS software.

Another every important thing with GIS softwares that you should have good help available, nowadays most of the very popular GIS softwares are having either online help or offline help available through the, but if the softwares which are not providing online help then I would not put them in a very good category of GIS softwares. Another very important thing is that because sometimes locally you may not be having expertise available within your organization. So, you sometimes when you are stuck in GIS in real projects, this is a very common thing that initially when you start working in GIS platforms, you find sometimes difficultly while inputting the data organizing the data or analyzing the data then you would look for help online help or offline help may not be sufficient. So, you would look some help by through some person.

So, these softwares GIS softwares should also support some discussion group nowadays good softwares are having their own discussion groups, so that you can raise your question and within few hours maybe 24 hours later you get the good answer, good reply, and good support from these discussion groups. Sometimes you can also contribute or help others if you know the answer about that particular problem by that person has risen. So, these are the certain criteria one should keep in mind when going or selecting GIS software.

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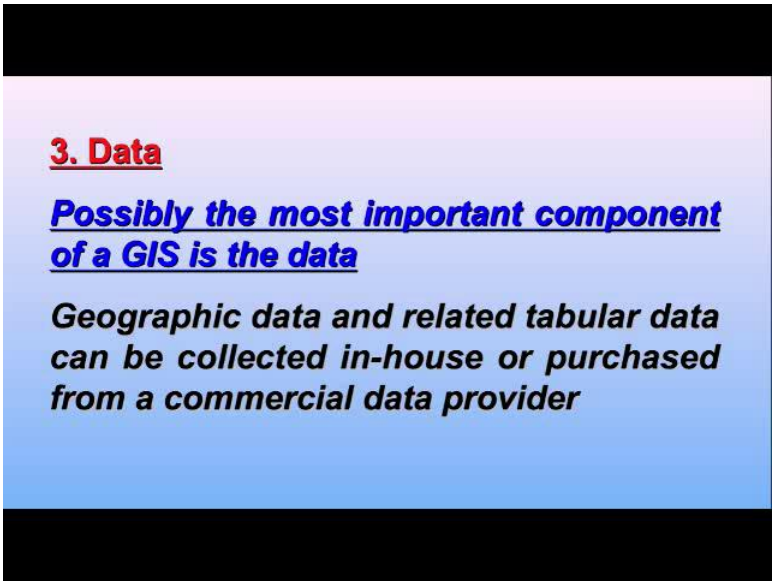

Now, third and in my opinion again very important component is the data as for the carpenter is a wood or material which he will use to prepare a furniture. Here we will make maps, or tables or reports; without data you may be having good hardware you may be having very most popular and most advanced GIS software, but if you do not have the data it is no use. So, data is another very, very important and that is why it is mentioned here that the possibly the most important component of GIS is the data. Without data your GIS cannot run like without wood carpenter cannot work. Now, GIS data and related a tabular data which I will come later which we call as non spatial data geographic data we call as a spatial data can be collected in house as a by definition coming from variety of sources. So, one might be in-house collection or purchased or available through some a sources. So, data can come from variety of sources in variety of formats and that is why a manipulation format conversion all kinds of conversions may be required in case of the data.

Now, the fourth and another important component the people, without people, now people includes both the GIS experts and users and decision makers all kinds of you know a full spectrum of people are required in a GIS. Otherwise, if there is nobody is an asking new solution from GIS then development of GIS will stop. So, you require as users purely as users end they do not know how GIS works; they do not know from

where the data has come, they do not want to bother that how you have organized the data. They just want to see the result like most of the people are using Google maps without knowing from where the data is coming, who is generating the data, they are just simply users. People also include the GIS experts those who collect the data, organize the data and maintain such systems maybe online systems like Google map or maybe offline systems in some organizations or large enterprise. So, people are another very important component of GIS.

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And GIS technology will be limited as I have already mentioned without the people and who will manage the system develop plans for applying into the real worlds. And the real users who would really exploit the GIS, and GIS users also range from technically specialists who design or write codes develop the software further and those who keep asking questions to the GIS expert that can you do this thing. And also mention in previous lecture there is a continuous process GIS operations are continuous you keep a developing something, people will keep asking more; and as you develop more they will keep asking more. So, they will compel the development this is how the GIS has developed. So, it is in many ways it is good.

Another very important thing when we start looking little bit to the first component in the hardware or computer technology overall which you also include the software technology that more developments when they are taking place in these two hardware and software slowly in after some time these development will also come into the GIS platform. So, the development in any such fields, ultimately will also peculate into the GIS domain and more hardware's are improving and becoming better faster and are capable of handling large volumes of data then our GIS also becomes rich. If softwares becomes very efficient new algorithms are developed new tools are there then slowly all these will finally, and ultimately also will peculate into GIS domain.

So, here GIS is getting benefited from all sources, whether it is a cartography any development takes place in cartography ultimately it will peculate into a GIS. Any development in computer science software, hardware or in communication that to will come. Similarly like in GPS technology, three years back we had only one global positioning system which was US based. Now we are having several including India is having our own GPS system like which we recently it has been renamed as NAVIC it was IRNSS system and it is regional system whereas, GPS or Gluons are global system Chinese have also developed a system which is called Baidu, so these that is global system. Now, a GPS receiver, which used to receive only signals from US based GPS or global positioning system, is may not be use in future.

Now, people are having a receivers which can receive signals from three four such systems, therefore the accuracy will improve. And this improvement in accuracy ultimately will also peculate into GIS; new applications also will develop in GIS. One very important thing in GIS regularly including remote sensing digital image processing we do is geo referencing; we do geo code a satellite image. So, because nowadays we are moving from higher and higher resolutions and therefore, very high quality or very accurate geo referencing is required. So, conventional methods of geo referencing may not work now. So, we require very high accurate data from GPS, and luckily all kinds of navigation systems are now available. So, we can definitively improve our accuracy of geo referencing. So, what I am trying to say that development in computer technology development in GPS technology, development in remote sensing technology,

development in cartography or cad cam design all finally, will also peculate into GIS domain.

Fifth and last, but not the least component of GIS is methods. Again, let me relate with the same carpenter's toolbox analogy. It is the design of the furniture. How to cut a wood, how to polish a wood, how to make a hole in the wood, which wood will be more suitable, where one can find the wood, so all these methods are very much required. In GIS like algorithms are there and as I have said that most of the things are coming from mathematical domain. So, if anything develops there if it has got use in GI it will come in GIS, maybe little latter definitely it has come. So, methods or designs are very, very important in GIS.

Now a successful as I mentioned here the successful GIS operates according to a well-designed plan business rules, and which are the models and operating practices unique to each other. Let me give you one example like somebody if he is working on say ground water flow, in new model on ground water flow estimation has come. It does not have so far any linkage with GIS, but very soon in future it will have a linkage; and once it develop the linkage that model itself becomes powerful and so GIS becomes enriched because of the linkage which has been established with that model.

And this is how initially all these models are developed in isolation, but more example I can give there is a very famous a model which is called universal soil laws equation model. So, this model was existing before the invention of GIS, but once the people have clubbed it or integrated with GIS that is the same USLE or universal soil law equation model or revised version are USLE other things have become much more powerful much more useful once they got the linkage with the GIS. So, there might be some tools available, models might be available in isolation. There may not be any linkage so far with GIS, but in future in my opinion they will have very good linkage if they handles the geographic data and then the tool itself the model itself becomes powerful.

So, the GIS so that is now in methods, methods have the input in data methods have about the you know organizing the data, methods about the changing the format, methods have about geo referencing accuracy parts and then finally, analysis and

modeling. So, these come and so these section of software GIS softwares slowly, slowly are also becoming very enriching. Let me one give you one more example like GIS handles large volumes of spatial data and sometimes you require data compression techniques.

Now data compression is a part of mathematical domain. So, more developments as they are talking place more new technologies which they are implementing in data compression ultimately ends up in GIS. For example, (Refer Time: 22:59) based data compression techniques, they have now peculated into GIS softwares. And GIS softwares will compress the data or sometimes you one has to buy a different compression tools available elsewhere you compress the data, decompress the data. So, they say all together different domain or a branch or mathematics, but the benefits which are being developed in mathematical branch or data compression also are coming later little later into GIS platform so in image processing or the remote sensing as well.

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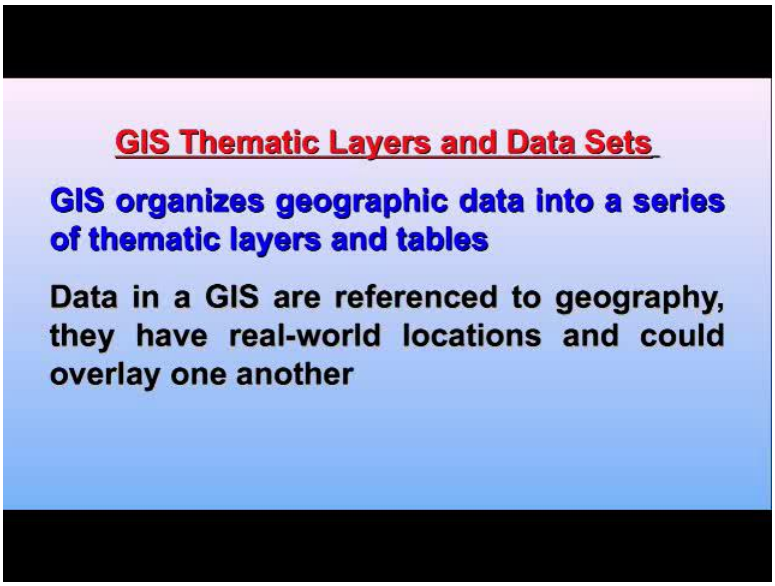

As I mentioned in the first lecture that we you know segment that natural ward into different components, different layers, different themes and this is how that we organize the data into geographic means we attach the location with each object. The object may be point data, object maybe the line data, polygon data or maybe image satellite image or

a photograph or a video or audio, everything we try to attach with the coordinates and those coordinates are geographic coordinate.

In our domain, we call as may be latitude longitude or in some other map projections may use different coordinates system, but all will fall in the geographic coordinate. And all these layers are organized in that fashion and then referenced the geo reference I have mentioned already, so it is reference with the coordinate geographic coordinate, so that we can extract all layers and top of each other. And whenever we want to use out of say I am having in my database 20 layer I want to use two or three or four at a time, I can very well use in GIS once they are geo reference to the geographic coordinate system. Any coordinate system, which we can use, means many in projections system I mean here.

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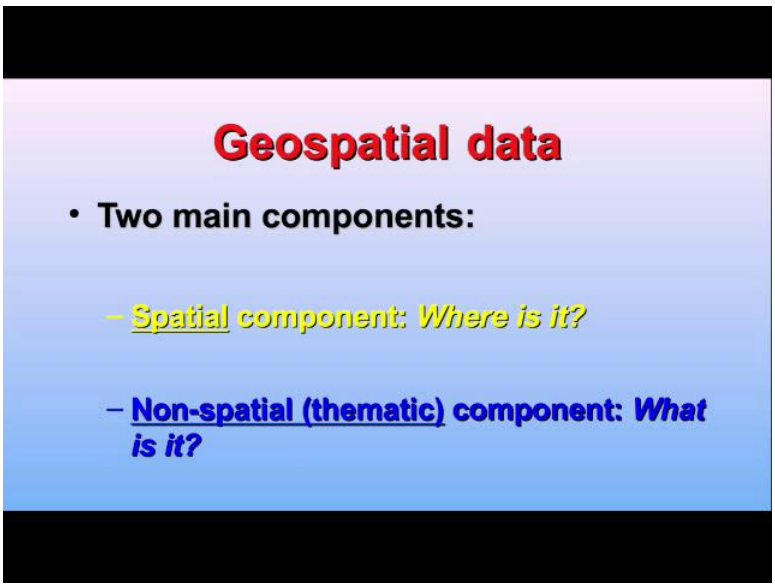

And as I mentioned also earlier that the geo spa al data. So, the data which goes into the GIS can be divided into two major parts one is which is spatial data which is having a real the object location. For example, you are having a location of a house, now location of a house is having x and y coordinates maybe also z coordinate, but z coordinate is a will go as a non-spatial data. How many people are living in that house, who owns the house, when it was constructed all kinds of information will go into non-spatial data and the spatial data is having just location. So, I give the example of point data, it will have x

and y. If it a line data it will have a series of x and y. And if it a polygon data then it will have a series of x and y, but the first coordinate and last coordinate is going to be the same.

So, like in case of satellite images, the location of a pixel will become very spatial data, but the value of the pixel will become a non spatial data or also we called as attributed. And the spatial data will answer your question that where is it the location, because it is having holding the location of an object. Whereas the non-spatial data will answer the question like what is it? So, like wise we keep organized the data in a fashion in GIS in a manner, so that we can retrieve very efficiently we can analysis in a very coherent and nice manner.

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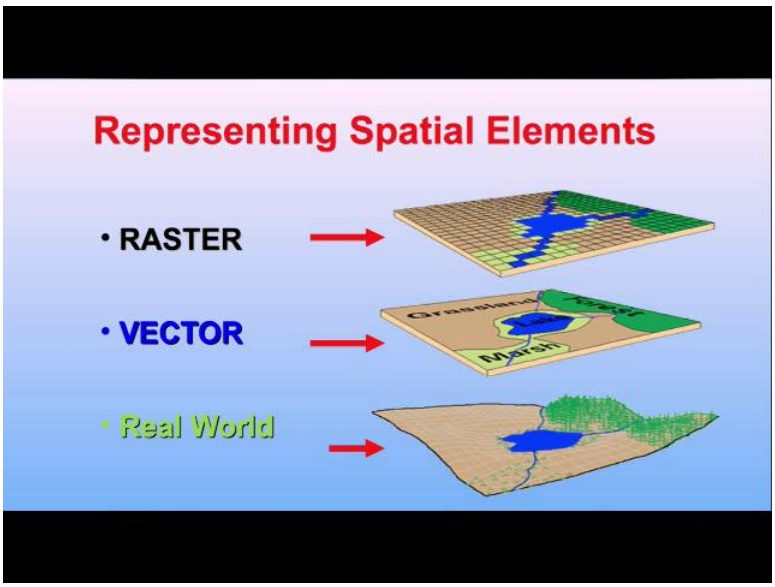

Now as you know that this thing we have touched little bit that the real world we try to segment it in different time types of data which in the next lecture we will be discussing what is vector, what is raster and different types of vector and other things. But we can segment the real world into maybe some layers of vectors might be having point line, polygons or may be some layers of raster maybe elevation information maybe a satellite image representing the land use, forest cover and all kinds of things are there. And then

associated non-spatial data or we call attribute data or in simple terms you can think like a tabular data.

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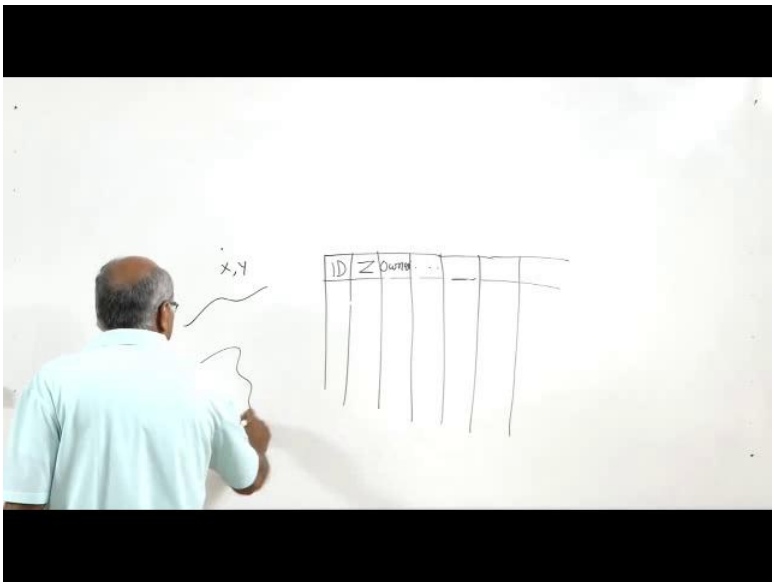

So, you are having an object and that object is suppose this is x, y, this is one point. So, it will have one x and y. So, it is just having location, it is a spatial data, but this point can have a table attached table like this. And can have say unique id which is essential for all spatial objects then you will have a maybe the z location, maybe the owner if it is a information about the house maybe the owner when it was constructed and so on and so forth. Now this part theoretically is unlimited that number of columns which you can have in your database in GIS database extended GIS database theoretically is unlimited, but a when you are really using GIS software then there might be some software limitations are there. So, one has to be little careful while creating more fields against one single spatial object.

Similarly, the same similarly kind of table can also be in case of a road or a street which is representing a line or poly line and similarly for an area you can have attribute table. So, attribute table will always store non essential data which is directly related with the spatial objects; it is not that it is lying in isolation and that is the beauty of GIS that spatial data and attribute data are having a direct linkage or dynamic link or hot link.

Otherwise, in late like cad systems, you do not have the database here you are having database as well as a spatial object.

So, this brings end of this presentation on components of GIS as mentioned in the beginning that in literature you might find few more components, but essential components I have already discussed here.

Thank you.