

# Network Analyst - An Introduction

This session is geared toward new or potential users of ArcGIS Network Analyst—an extension designed to model road networks and solve transportation-related problems. Network Analyst is often used to route vehicles or fleets of vehicles, generate service areas, and perform site-selection analysis. The presenters will cover the basics of the extension’s modeling and analytic capabilities, including network creation, use of analysis tools in ArcMap, and integration with the geoprocessing framework.

[http://video.esri.com/watch/92/network-analyst-\\_dash\\_-an-introduction](http://video.esri.com/watch/92/network-analyst-_dash_-an-introduction)

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## Video Transcription

**00:01** So my name's Patrick Stevens. I'm a product engineer on the Network Analyst team.

**00:04** And I'm Robert Garrity. I'm also a product engineer on the same team.

**00:07** And we, as product engineers, we work closely with the developers designing the software, testing the software...

**00:12** ...doing SDK work, and things like that.

**00:17** Oh, and I also wanted to mention one other thing: there's another type of network that ArcGIS covers...

**00:21** ...and that is geometric networks.

**00:24** And those, instead of street networks or transportation networks, like we work on with Network Analyst...

**00:28** ...those are utility and natural resource networks.

**00:30** Directed flow, like electricity or rivers.

**00:33** And if it's that type of network that you're interested in, public utilities and...and such...

**00:37** ...then there's a presentation going on right now in room 3 about geometric networks.

**00:41** And there's another one later on, I believe...

**00:42** It doesn't maintain geometry internally while it's solving, and it doesn't produce it when it's done.

**00:44** When we get to the end, I'll show you the time for another one if you're interested in both kind of networks.

**00:48** So sorry if it's a little bit confusing.

**00:52** So Network Analyst is an extension of ArcGIS that allows you to perform analysis on a transportation network...

**00:59** ...as I said; like streets, for example.

**01:01** So if routing's a part of your job, then Network Analyst will be valuable to you...

**01:04** ...help your organization save money, help you look like a hero.

**01:08** So you see here the types of analysis we support.

**01:11** These types are performed by what we call solvers. That's the term I'll use throughout this presentation.

**01:16** And they... Solvers perform these...these algorithms on the street networks, of analyzing the networks...

**01:22** ...including finding the best route through a set of locations, considering time windows and sequencing...

**01:28** ...finding the nearest location from another location or sets of locations...

**01:33** ...determining the area that's accessible around a facility location within a given cost or time service area...

**01:41** ...finding a table of costs from a set of origins to a set of destinations...

**01:48** ...optimizing a set of routes with a fleet of vehicles with the vehicle routing problem solver.

**01:53** And new at 10.0, we're finding the best possible place to put a facility...

**01:57** ...be it a warehouse, a station, or a bus stop, based on allocating demand efficiently.

**02:03** So in this presentation, we're going to start out with going over how and where you'd work with Network Analyst in ArcGIS.

**02:10** And then we'll talk a little bit about modeling street networks using our data model, which is called the network dataset.

**02:15** We'll talk about each of these six solvers that I've just showed you and do a demonstration of each of them.

**02:20** And then we'll go over a little bit of where you can further your Network Analyst education here at the Users Conference.

**02:26** So the first thing you'll need to do with Network Analyst is enable the license.

**02:30** So you need a network analysis license, and you'll enable it with the Extensions dialog...

**02:35** ...that you'll see here that Bob will show you in a little bit.

**02:38** Now Network Analyst is a complete GIS.

**02:40** And what that means is we do visualization, we do analysis, we do data management, and we do dissemination.

**02:47** And the data management portion of that is via the network datasets.

**02:51** That's our core geodatabase model to represent undirected network or street networks.

**02:56** And we're going to cover the power of this data model in a little bit through some slides and demos.

**03:01** So you'll manage this data, these network datasets, within ArcMap.

**03:05** That's where you do editing and viewing of the data.

**03:07** And in ArcCatalog is where you'll do the creation wizard or building of the network.

**03:12** And new at 10, you can dissolve and...and version networks.

**03:14** And we'll go over that a little bit.

**03:16** And now you can use the Arc...the Catalog window within ArcMap at 10.0.

**03:23** So then you'll set up your analysis problems, and you'll do that within ArcMap or via geoprocessing.

**03:27** And with that you'll work with the six solvers.

**03:30** And this is the nitty-gritty of network analysis.

**03:32** Your data's set up as network datasets, and you're creating scenarios in...in solving network problems or transportation problems.

**03:41** And at 10.0, you can work with the 3D capabilities of Network Analyst using three-dimensional network datasets.

**03:46** You'll do that in ArcScene and ArcGlobe.

**03:48** And there's no out-of-the-box controls for Network Analyst in those two apps.

**03:52** But all the geoprocessing tools are available, so you can do anything with Network Analyst that you want in three dimensions.

**03:59** So the dissemination part of Network Analyst is serving out network analysis services.

**04:04** And you'll serve those analysis maps through ArcGIS Server...

**04:07** ...by publishing either as geoprocessing services or as a network analysis service.

**04:12** By you... When you publish your service, you'll click the appropriate setting; it'll publish in the method that you choose.

**04:17** And if that's what you want to do, there's a seminar on automating workflows using geoprocessing that'll...

**04:21** ...help teach you how to use ArcGIS Server with Network Analyst.

**04:25** So after you publish your services, they can be accessed via the REST or the SOAP endpoints...

**04:31** ...in various frameworks, the Web APIs like Silverlight and Flex and JavaScript.

**04:35** Or you can use ArcMap and ArcGIS Explorer to connect to these connections as well.

**04:41** Also I wanted to mention, if you are brand new to Network Analyst, please go through the tutorial.

**04:45** You can install the tutorial with the tutorial data.

**04:48** And it doesn't take very long, and it gives you a great overview of how to use the product and what it's capable of.

**04:54** So in ArcMap, you'll want to use this Network Analyst toolbar pretty extensively.

**04:59** With it, you'll create new analysis layers, you can add inputs to your analysis...

**05:03** ...you'll solve the problems and generate directions and work with the network dataset.

**05:07** You can also activate what's called the Network Analyst window or, as we call it, the NA window.

**05:11** And that'll help you manage the inputs to each of these analyses, as...as well as manage your results.

**05:18** There's also a complete set of geoprocessing tools, as I mentioned, in...in ArcMap as well as in ArcScene and ArcGlobe.

**05:24** And anything you can do with Network Analyst through the toolbar, pretty much you can do through geoprocessing as well.

**05:31** Now, Network Analyst is represented in ArcGIS the same way that other datasets are, and that's through layers.

**05:36** You see here a table of contents with two layers shown.

**05:39** The layer on the top is a network layer, and that references your network dataset on disk.

**05:44** And the layer on the bottom is the network analysis layer...

**05:46** ...and that holds the definition of the analysis that you're concerned with, that you're working with.

**05:51** It's a composite layer that's made of sublayers like routes and stops and barriers as you see here for a route layer.

**05:57** Now there's layers for each of the six types of analysis that I showed you.

**06:00** But you'll work with all of them in the same way.

**06:05** So Bob will show you some of the modeling capabilities of the...the network dataset.

**06:10** Okay. Thanks, Patrick.

**06:13** Let's see; try to get my microphone working so you can hear me.

**06:16** Okay. The first thing that I like to do when I open up a fresh installation of ArcGIS is add the Network Analyst toolbar.

**06:24** Do that by clicking Customize, Toolbars, and Network Analyst.

**06:28** And then I'd add the Network Analyst window.

**06:31** And to do that, I would click this button, but it's disabled.

**06:33** And that tells me that I haven't enabled the Network Analyst extension yet.

**06:37** So I'll go to Customize, Extensions, that'll open up the Extensions dialog box, and I just check on the extension here.

**06:44** And it's...and you can see that the...the Show Network Analyst Window button is available now.

**06:51** So I click there, and it's opened up the Network Analyst dialog box, which is here.

**06:56** This will help me manage the inputs and outputs of my network analysis layers.

**07:01** And I'll switch back to my table of contents because I'm going to add a network dataset to my map.

**07:07** So to do that, I use a new Catalog window, and I'll look for my network dataset layer, or network dataset in this case.

**07:15** And it's... I can recognize it by the grid pattern with the route that's drawn on top of it...

**07:20** ...and I'll just drag that into the map and drop it.

**07:23** And it asks if I want to add the source features that come with it.

**07:27** I'm just going to say no for this analysis.

**07:29** And here we have a map of...of San Francisco.

**07:34** Just going to zoom in here.

**07:35** And notice that it added the network layer.

**07:38** I call it the network dataset layer just to make a...

**07:41** ...make it more distinct between a network dataset layer and a network analysis layer.

**07:45** And now that I have a network dataset layer in the map, I can create a network analysis layer.

**07:51** And to do that, I just click the drop-down menu in the Network Analyst toolbar and choose the type of analysis I want to perform.

**07:59** I'll choose Service Area in this case.

**08:01** And now if we look at the Network Analyst window, the service area analysis layer is shown here.

**08:08** Just going to create a facility by using the Create Network Location tool on the toolbar, and solve.

**08:16** And this will give me a five-minute service area around that facility.

**08:21** That's a quick overview of how you use Network An-...the UI components in Network Analyst.

**08:32** So when you think about how you get from one location in town to another location in town, what does it take?

**08:39** You have to get in your car, you drive along the streets, you obey the speed limits, you stop at traffic lights...

**08:44** ...you drive on the correct side of the road, you try to take what you think is the quickest route to your destination.

**08:49** And when you get there, you make sure that you park on the right side of the road for the place that you're visiting.

**08:55** And it's our job to make a computer model that'll accurately reflect these conditions along a road network.

**09:00** There's the conditions like the traffic laws I mentioned, as well as transitory conditions like...

**09:05** ...congested traffic, weather, road closures, those kind of things.

**09:09** And we'll do this through our network dataset model through static road conditions...

**09:13** ...things that are inherent to the street network like speed limits...

**09:16** ...as well as settings on the solvers that we offer for the more dynamic road conditions...

**09:21** ...or things that are only appropriate to the analysis you're doing, like the placement of the stops.

**09:26** Now, this is the... One of the many things that differentiates Network Analyst from our competitors...

**09:30** ...it's that we provide a full set of tools that'll...that'll help you model the world.

**09:33** The better the model, the more accurate the routes'll be.

**09:36** Bob will go over the network dataset model with you now.

**09:39** Okay. Let's see. To start using Network Analyst, you need data...

**09:43** ...and Network Analyst supports source data in the form of shapefiles; file, personal, and SDE geodatabases.

**09:51** It also supports StreetMap data, which is compressed and read-only.

**09:55** Where can you get this kind of data?

**09:56** We have a few options.

**09:58** You can use the free Data & Maps DVD that comes with ArcGIS.

**10:02** That contains nationwide street map data.

**10:06** You can also convert U.S. Census TIGER data into a network.

**10:12** And...and a new option that's available just a...is one that Esri made available on Friday...

**10:20** ...was an ArcGIS Editor for OpenStreetMap.

**10:23** So you can also use OpenStreetMap data; just download that onto your computer...

**10:27** ...and then convert that into a network dataset.

**10:30** The ArcGIS Editor for OpenStreetMap was designed so that you can contribute for the crowd sourcing project.

**10:38** So you can add streets, add information.

**10:40** And then lots of people around the world, they're doing the same thing...

**10:43** ...and then you create your own network dataset from that information.

**10:48** You can also use your own feature classes that represent roads or transportation networks.

**10:53** Vendors like Tele Atlas and NAVTEQ also supply network data.

**10:57** You'll need to pay for it, but it is really high-quality data.

**11:02** And the data you'll use represents networks.

**11:04** An important concept to understand is the difference between Euclidean and network paths.

**11:09** So how do you travel from one place to another?

**11:11** Say I want to get from point A to point B in this slide...

**11:14** ...and if I take a straight-line path, I would be taking the Euclidean path.

**11:19** But that would require swimming, and I probably wouldn't want to jump into that lake.

**11:22** So instead, what I would do is travel along the roads that go around the lake.

**11:27** And we call this path the network path.

**11:31** Finding network paths is a fundamental ability of the Network Analyst extension.

**11:35** And since people and goods tend to travel on network paths, its modeling and analysis tools are valuable.

**11:44** So to correctly find these network paths, you also need to be able to accurately model your network dataset.

**11:51** And the Network Analyst team has put a lot of effort into providing tools that will allow you to do this.

**11:57** And one of the characteristics you need to be able to model is connectivity.

**12:01** This is about how streets connect to one another.

**12:04** Think about the lines, just normal lines in a simple feature class, a line feature class.

**12:10** One line doesn't know that another line crosses it or even that another line exists.

**12:14** But the network dataset, it keeps track of this information and knows what lines are connected...

**12:19** ...so that it can quickly determine which lines or which paths along the network are possible.

**12:24** It also allows you to set rule that...set rules that allow you to specify which intersecting lines truly connect.

**12:32** This way you can model multimodal networks, overpasses and complex interchanges like the one shown here.

**12:40** And each line, or edge as we call it, is...has attributes.

**12:45** And there are four types.

**12:46** You can have a cost, restriction, and...let's see...descriptor, and hierarchy attributes.

**12:52** The most important of these is the cost attribute because all solvers or analyses you perform minimize the cost.

**12:59** And whenever you create a network dataset, you need to provide at least a cost attribute.

**13:04** And a moment ago, I was talking about finding a path around a lake...

**13:07** ...and what I showed you was actually the shortest path, the graphic on the top.

**13:12** It's the route that minimized the distance traveled.

**13:15** And distance in this case was the cost.

**13:17** And as we see here, it was 25 miles long, so we say the total cost was 25 miles.

**13:22** To minimize distance, each edge or street needs to have an associated cost attribute, and that cost is in miles in this case.

**13:32** And using distance as a cost attribute can be good when you're finding a route for a person who's walking.

**13:38** However, if your route is for a person who's driving, you'd probably want to minimize the driving time...

**13:43** ...which is a function of distance and speed or speed limits. In this case, each edge needs an associated driving time.

**13:52** As these demon-...as these graphics demonstrate, the paths could be different...

**13:55** ...depending on whether you're minimizing distance or driving.

**14:00** And if you see, on the top one, person who would walk would walk through the city...

**14:04** ...because it doesn't really matter if you're walking on streets or country roads.

**14:08** But down below, you would take the path through the country so that way you don't have to stop at stoplights and stop signs.

**14:18** A single network dataset often has multiple cost attributes.

**14:21** This way you can find the shortest path from...for one analysis and then find the quickest path for another analysis.

**14:28** You can even include other kinds of cost attributes in your network dataset as well.

**14:34** So we've been looking at costs on edges. And...but network attributes always span edges, junctions, and turns.

**14:42** So that means that the junctions at the ends of edges and the turns that model transitions from one edge to another can also have costs.

**14:52** So I'm going to show you an example of a turn delay.

**14:54** So the orange line here represents a simple route from point A to point B.

**14:59** And the first road segment takes five seconds to traverse, and the second road segment takes another five seconds...

**15:04** ...so it's a total travel time of 10 seconds.

**15:07** But there's a left-hand turn light and some traffic there, so on average, it takes 15 seconds just to make that turn.

**15:14** So what we can do to model this is add a turn feature, and...

**15:18** ...represented by the yellow arrow, and then assign a cost of 15 seconds to that turn.

**15:24** And then that changes the total cost of the...the route to 25 seconds.

**15:31** But digitizing all the turns in a network would take a long time, so that's why we offer the global turn delay evaluator.

**15:37** Global turns add a cost to every two-edge turn sequence in the network, unless a turn feature is already there.

**15:44** In that case, the turn feature would override any global turn delay.

**15:48** So this means that all you need to do is digitize the most important turn delays using turn features...

**15:53** ...and then you can use the global turn delay evaluator to generically model the rest.

**15:58** And all you need to do to create global turns is to fill out the dialog box shown here.

**16:03** And one nice feature about this is that you can specify turns based on turn type and road class.

**16:08** So if you're taking a left-hand turn, you can have that cost more than a right-hand turn.

**16:13** Or if you're making a left-hand turn from a local road onto a highway...

**16:18** ...that would take longer than a left-hand turn from a local road onto another local road...

**16:22** ...because when you're trying to get onto a highway from a local road, you typically have to wait for a gap in traffic...

**16:28** ...and it takes longer.

**16:30** So here's a new feature that we added in the release of ArcGIS 10, historical traffic.

**16:35** And its purpose is to capture how travel times change throughout the day and throughout the week.

**16:41** So if you have a traffic-enabled network dataset, what you do is you provide a day and a time of day...

**16:47** ...and then Network Analyst can determine the best route based on that time.

**16:51** So here, the best route at 8:00 a.m. is along...from the city to the suburb is along the divided highway.

**16:57** But at 6:00 p.m., the quickest route changes to the winding road on the left of the divided highway...

**17:02** ...because there's more traffic going out to the suburb.

**17:05** And it's important to note that Network Analyst won't just tell you...or won't just determine if there's traffic on a road and avoid it.

**17:12** It'll determine what's better.

**17:13** Is it better to wait in traffic?

**17:15** Is it quicker that way?

**17:16** Or is it quicker to find an alternate route?

**17:21** So far, we've looked at the usefulness of cost attributes, but we also have restriction attributes.

**17:26** And these allow you to model things like one-way streets, blocked intersections...

**17:29** ...and turns that are prohibited by law.

**17:32** You can turn these restrictions on and off when you solve an analysis.

**17:35** So if you're finding the best walking path, you would turn off all these restrictions shown here.

**17:39** But if you're going to find the best driving route, then you would turn these restrictions on so you don't break the law.

**17:46** And another kind of attribute is a descriptor attribute, and it just describes a particular characteristic of the network.

**17:53** It's not actually used by the solver, but what it's...

**17:56** ...it's often used by is another restriction attribute to model a more complex restriction.

**18:01** So let's say we have a descriptor attribute that stores the minimum clearances of bridges or overpasses.

**18:07** So by itself, it wouldn't do anything, but if a...so a vehicle would still be routed underneath overpasses that are too low for them.

**18:15** But what you can do is have a corresponding restriction attribute that references this descriptor attribute...

**18:20** ...and also a vehicle characteristic that you enter at solve time, such as the vehicle height, then...

**18:27** ...the route would avoid low overpasses.

**18:31** So what I've shown you so far is mostly static characteristics of the road network, and they're built into the network dataset.

**18:39** So the height of the overpass and the connectivity of the streets won't really change that often.

**18:44** But what about temporary changes to the network that you can change when you're performing the analysis?

**18:51** One of those changes would be the U-turn policy.

**18:53** And this is about allowing or prohibiting U-turns at intersections.

**18:59** So sometimes the quickest way to get from one place to another involves a U-turn.

**19:02** It...it takes a long time to make a left-hand turn...

**19:05** ...it might be quicker to go straight through the intersection to the next intersection, make a U-turn, come back...

**19:10** ...and then turn right and go onto the same street you had originally intended to go on.

**19:15** But maybe you don't want to make these kinds of questionable maneuvers...

**19:17** ...or the vehicle you're driving, it really makes these kinds of maneuvers difficult.

**19:22** So what you can do is prohibit U-turns at intersections.

**19:27** We also have restriction barriers, which allow you to model parts of the network that are currently inaccessible.

**19:33** So when river covers a road and makes it inaccessible, what you can do is simply create a barrier at analysis time...

**19:43** ...and then when your analysis will restrict access...access to those roads.

**19:49** But once the water recedes, all you need to do is delete the barrier, and then you're...

**19:53** ...you can re-solve your analysis and have access to those roads again.

**19:56** And the same is true for when a boulder falls on the road or a sinkhole forms.

**20:01** You just add the restriction barrier, and once the boulder is removed or the sinkhole is filled, which might take a while...

**20:08** ...but you could just delete it and use the roads again.

**20:14** The scale cost barriers are a lot like restriction barriers, but instead of restricting travel completely...

**20:19** ...what we do is scale the cost of traveling on the roads.

**20:23** So, for instance, you can create a scale cost barrier to represent a snowstorm...

**20:27** ...and the barrier will only increase the travel times of the roads it covers.

**20:31** Once the storm is past, you can just delete the barrier and the travel times go back to their normal times.

**20:37** And the same idea is true for roads that are under construction.

**20:41** Curb approach specifies which side of the road you want your vehicle to be on when you arrive at a stop.

**20:47** So if you look at the slide on the left side, we see the school bus has arrived at the school.

**20:52** And since the school is on the left side of the bus...

**20:54** ...the students have to cross the road, and this exposes them to a little bit more danger than the students on the right side of the slide...

**21:02** ...who are dropped off on the same side as the school, so they don't have to cross the road.

**21:06** And when you load or unload a truck, you also want to keep this in mind so you don't have to carry your cargo across the street.

**21:13** So I'm going to give you a quick demo of some of these capabilities.

**21:17** And the purpose of the demo is...

**21:19** I'll show you using a two-stop route.

**21:23** And the purpose of the demo isn't to show you that Network Analyst solves routes or how to use the user interface controls.

**21:31** Rather, it's to show you or highlight the modeling capabilities of the network dataset...

**21:35** ...and show you that how you model the network dataset affects your analysis results.

**21:41** So I have two stops; I'm going to walk from the first stop down to the second stop.

**21:47** And I'm going to open up the analysis properties, and I'm going to use a distance-based cost attribute to solve the analysis.

**21:56** And this gives me the shortest path.

**21:59** But there's a lot of Dumpsters and alley cats along this route...

**22:05** ...so I've determined that this is not really within my walking distance anymore.

**22:09** I would rather use my car instead.

**22:12** So what I do is create a drive time or use my drive-time cost attribute, and then solve again.

**22:20** And I get a slightly longer route.

**22:22** And instead of going on these roads that we went on when we were walking, it takes these roads.

**22:28** The reason is, is that the speed limits along here are faster than the speed limits along here.

**22:34** Now, let's see. I'm not including the rules of the road in this analysis yet.

**22:41** So I have one-way streets that I need to consider.

**22:44** I'm driving against a one-way street here, which is not going to work.

**22:47** I have restricted turns, so all these red arrows represent illegal turn maneuvers.

**22:54** And then I also have a turn delay here.

**22:57** There's a left-hand turn light that takes, on average, 25 seconds to drive through.

**23:01** And there's a dedicated left-hand-turn lane here too.

**23:05** And I have a height restriction.

**23:07** There's a pedestrian bridge that crosses this road, and the minimum clearance of it is 12 feet, 6 inches.

**23:13** And I also want to show you traffic.

**23:16** So to show you traffic, just to visualize it, I'm going to use time in the ArcGIS and I just enable time on the map.

**23:24** And I'm going to take my trip at 3:30 p.m. on Wednesday, so I've already entered that information here.

**23:30** And what we see on the map is the roads are color coded.

**23:35** And here we can see what the color codes mean.

**23:38** So red is stop-and-go, and it goes on up to green, which is free flow or unimpeded traffic.

**23:45** But I also have to set this information in my network analysis.

**23:48** So I'm going to check on all these restrictions...

**23:51** ...and, let's see, my vehicle height is 6 feet tall, and I'm also going to use a start time of 3:30 p.m...

**23:58** ...and I'm going to travel on Wednesday.

**24:01** And I'll solve, and I get a different route.

**24:04** And this time, it makes a left-hand turn here...

**24:08** ...and then goes underneath the pedestrian bridge and then arrives at the second stop.

**24:13** Now, if I was driving a truck instead of a car, then what I would do is just tell the analysis that my vehicle is 13 feet tall.

**24:23** Then solve again and get a slightly different route, or actually, pretty dramatically different route.

**24:29** Now, I'm going to go in here.

**24:31** I have turn delays enabled currently, but let's see.

**24:37** Actually, I need to turn on my historical traffic; I didn't assign that before.

**24:46** Okay. And I'll re-solve.

**24:48** Okay, this is the route that I was actually expecting.

**24:50** And this has three left-hand turns.

**24:53** And when I'm driving a semitruck, I don't really want to make left-hand turns unless I have a protected intersection.

**24:57** What I mean by that is that I have a left-turn light and that'll stop traffic from going for me...

**25:04** ...and that way, I can make a left-hand turn pretty easily and safely.

**25:08** So I can use the global turn delay evaluator.

**25:10** So I go to my network dataset and...

**25:12** ...open up the Global Turn Delay Evaluator dialog box...

**25:19** ...and here I assign different turn delays based on the turn type and road class.

**25:27** I'm just going to scale up all my left-hand turn lane...left-hand turns to take 10 minutes...

**25:33** ...so that'll essentially make left-hand turns...or prohibit them in the analysis.

**25:38** And then I'll re-solve.

**25:40** And here I get a different route without any left-hand turns.

**25:43** Instead, I make a right-hand turn, a U-turn, another U-turn, and then two more right turns.

**25:48** But if I'm not making left-hand turns, I probably don't want to make U-turns either...

**25:51** ...so I can shut those off in my analysis and say they're not allowed.

**25:58** I'm also going to take a look at the curb approach.

**26:00** And, see, I'm approaching the second stop, so it's on the left side of my vehicle...

**26:04** ...and since I'm driving a truck and I'm going to unload it, I don't want it to...

**26:07** ...I don't want to have to carry the cargo across the street.

**26:09** So I'll change the curb approach of that stop to right side of vehicle...

**26:15** ...re-solve, and now I'm arriving at the...the correct side of the road.

**26:20** Let me zoom out.

**26:23** And notice I'm also not taking any left or U-turns. Okay.

**26:29** And lastly what I want to show you are the barriers.

**26:33** So we have some construction on a road here, and one of the...

**26:37** This construction has slowed down traffic, so it's about 10 times the normal speed.

**26:40** One of the construction workers has broken a water main, and he's flooded out these roads here, and it blocks my road.

**26:47** I'm going to load the construction as a scale cost line barrier, and then I'll load the flood as a restriction barrier.

**27:04** And then I re-solve, and I'll generate directions while I'm doing that too.

**27:09** Minimize those for the time being.

**27:10** And now I'll just go over this route really quickly with you.

**27:14** Leave the first stop, make a left-hand turn.

**27:16** Even though I've used global turn delay evaluator to essentially prohibit left turns...

**27:20** ...I have a turn feature there, and that has a cost attribute on it.

**27:24** So it's not a prohibited left turn since...

**27:28** ...if you remember, I told you that turn features with cost attributes override the global turn delay evaluator.

**27:34** And that's what's happening here.

**27:35** So this allows you to model dedicated left-hand-turn lanes.

**27:40** And then you can drive down here, and it doesn't make a right-hand turn here because you've got a turn restriction.

**27:45** It goes past this road; there's a one-way street going in the other direction.

**27:49** It'll take this one-way street and make right-hand turns for the rest of the trip.

**27:53** It enters into the scale cost barrier, and for this portion of its trip, it goes 10 times...

**27:59** ...it takes 10 times longer than normal, and then arrives at the second stop.

**28:03** And this is actually the quickest route from point...stop 1 to stop 2 given all the criteria I've given it.

**28:09** And then, I can take a look at the directions; this gives me turn-by-turn instructions.

**28:15** And I can also take a look at inset maps and highlight the turn with the highlight arrow.

**28:23** So that's just a quick overview of the network dataset modeling capabilities.

**28:30** And the things I want you to remember from that is I network dataset modeled the roads and the cost attributes...

**28:34** ...modeled the best pedestrian and driving paths.

**28:37** And we're able to model both static and dynamic modeling capabilities, and they changed the results of the analysis.

**28:47** So I'll turn it back over to Patrick to talk about the different types of analysis we offer.

**28:53** Thank you, Bob.

**28:54** And if you ever need to deliver something during a flood in Chinatown in San Francisco...

**28:58** ...now you guys'll know the correct way to go through all the one-way streets and all of that.

**29:04** So we showed you the six types of analysis at the beginning of the presentation, and we call those our solvers.

**29:10** And what Bob demonstrated was network dataset capabilities, but he used the route solver to do the demonstrations.

**29:17** So this route solver helps you find the best way to get from one location to another location...

**29:22** ...or to visit several locations along the way.

**29:25** And we call these locations stops in the...in the route analysis.

**29:28** You see in the image a four-stop route; it starts in the bottom right and...and...

**29:33** ...and is optimized going from that stop 1 all the way to stop 4.

**29:36** Now those stops could have been added to the route by clicking on the map interactively...

**29:41** ...and it would snap the location to the network.

**29:43** Or you could've entered an address in the geocoding...

**29:47** ...with the geocoding capabilities, that would've geocoded that address to a point along the network.

**29:52** Or you could've loaded the points from an existing feature class or feature layer.

**29:56** Now with the route solver, there's a few options available to you, including time windows.

**30:00** And these are a property of the stop.

**30:02** And the route will help optimize when you want to visit that stop according to the time window that you set for...

**30:07** ...for the...to...when best to visit.

**30:11** Now the best...the best route can be determined in the order of locations specified by the user; in this case, 1, 2, 3, 4.

**30:17** It'll find the shortest path from 1 to 2, from 2 to 3, from 3 to 4.

**30:21** Or you can set the route solver to find the best sequence for you and do what's called the traveling salesperson problem...

**30:26** ...where it will optimize these stop...it'll optimize the stop order for you.

**30:30** And that's if you don't care when you visit the stops; you just want to get to all four of them...

**30:34** ...you can have the route solver do that.

**30:36** You can also create multiple routes.

**30:38** You can specify the start time of the route, which you have to do if you're setting time windows.

**30:43** And you can generate text directions for the route after it's been solved, as you saw Bob do.

**30:47** And these directions can be exported as...

**30:50** You can print them out or export them as CSV files or XML files to send to drivers and to distribute electronically.

**30:56** As with all the solvers, you can add point, polyline, and polygon barriers if you want.

**31:02** These barriers can be restrictive or additive for points.

**31:05** So you can either block traversal or add some cost to the traversal...

**31:09** ...like it takes an extra minute to go through this area, or this tollbooth costs an extra few dollars.

**31:14** With polylines and polygon barriers, you can either restrict the area underneath the barrier...

**31:18** ...or you can scale the cost within that barrier to make sure it's a little bit slower.

**31:22** You might have seen in the plenary when he scaled Cleveland...

**31:25** ...using a barrier that represented inclement weather in the form of snow.

**31:30** So the route solver can be used in anything you need point-to-point routes for...

**31:34** ...for example, organizing your days' worth of orders for one vehicle or inspector.

**31:39** You can also access a free Network Analyst routing service via the Find Route tool within ArcMap and ArcGIS Explorer as well.

**31:46** And that'll give you some simple point-to-point routing capabilities without needing the Network Analyst license.

**31:52** So say you want to find the nearest hospital to an EMS incident or route the three closest police cars to a bank robbery...

**31:59** ...or find the nearest ATM to your house, you'll do that using the closest facility solver.

**32:04** Now this solver can be applied to emergency vehicle dispatching, to finding the nearest store to a customer...

**32:09** ...or any use where you want to pick out a set of locations from the starting or ending point.

**32:14** Now the scenarios are set up with what we call facilities and incidents with this solver.

**32:19** Those are the names of the subclasses in the Closest Facility layer.

**32:21** If you're setting up an EMS dispatching scenario for someone who called 911 from their house...

**32:26** ...the closest facility solver would find the nearest facility or ambulance from the incident or accident site.

**32:33** Now you can set a cutoff, for example, if you only want to find the police cars within 15 minutes of this bank robbery...

**32:38** ...and you want to ignore the other vehicles outside of 15 minutes.

**32:42** Or you can set a limit to the number of facilities to search for; only give me the five closest gas stations from my house, for example.

**32:50** Now streets can have traffic modeled differently for each direction of travel, as you saw with one-way roads...

**32:54** ...for example, or turn restrictions.

**32:57** So you can generate your routes considering travel from the facility to the incident...

**33:01** ...like routing fire engines from a fire station to a fire incident...

**33:05** ...or from the incident to the facility, like taking a burn victim from the scene of the fire to the nearest hospital.

**33:10** And note that you can also perform multiple closest facility analyses simultaneously if you have...

**33:15** ...multiple incidents and multiple facilities.

**33:18** So I'll give you a quick demonstration of...of dispatching using the closest facility solver.

**33:25** Now this is a simulation of fire and police dispatching using the solver that I just talked about.

**33:30** It's a Web application written against a Flex API accessing the closest facility solver via the REST endpoint.

**33:38** So it's an ArcGIS Server application.

**33:41** Let's see if I can...I was getting a little slow response earlier today; and it's all running local on the machine.

**33:47** So I can click on the map, and...and it'll geocode an incident.

**33:52** Let me refresh this.

**33:57** Set up my solver again, get my police cars moving.

**34:05** Slow network connection, looks like?

**34:07** Yeah. There they go.

**34:09** Okay. So you clip on...click on the map, and it'll snap to the network and find the nearest three police cars.

**34:14** I've chosen a police incident.

**34:16** I'll click on the fire department incident and click, and it'll find the nearest three engines.

**34:21** Or I can geocode an incident by entering an address and choosing a general incident type...

**34:25** ...which will just get the nearest three vehicles.

**34:30** So granted, this app is a simple version of dispatching...

**34:33** ...but the important thing to note is how the nearest vehicles are located and dispatched...

**34:38** ...and that...that there's a count of three of them.

**34:40** And that the network analysis can happen across ArcGIS Server with GPS tracking of the vehicles without a problem.

**34:46** Currently the route, closest facility, and service area solvers are available as REST endpoints...

**34:53** ...and there's SOAP endpoints for all six of the solvers.

**34:56** And you can also do geoprocessing and publish any Network Analyst workflow you want to.

**35:01** And this is fun to play with too.

**35:07** And you're welcome to see this demo later on if you want to...want to work with it a little bit.

**35:11** [Audience question] Could you set up separate network analysts for your police vehicles, your fire trucks?

**35:17** [Audience question] 'Cause you could set things like U-turn restrictions.

**35:20** [Audience question] I mean, a police car can make a U-turn at a median where a fire truck can't [unintelligible]

**35:25** The question is, Would you set up separate Network Analyst scenarios for police versus fire?

**35:30** You'd probably use the same network dataset...

**35:33** ...but within the analyses themselves, you can turn on or off restriction that apply only to those type of vehicles.

**35:38** So you could set the...the restrictions you would set for fire engines against the restrictions you would set for police cars...

**35:43** ...and you could solve them separately.

**35:44** In this case, it was just they're all considered the same thing.

**35:48** They were all facilities in the closest facility problem and it's dispatching them to the nearest incident.

**35:56** So from that demonstration, you see they used the closest facility solver to route groups of vehicles to a location...

**36:02** ...or groups of facilities, is the term we use...

**36:04** ...and that the solvers can reroute moving vehicles using GPS tracking even though this was a simulation.

**36:10** And this was all done through Web service through ArcGIS Server.

**36:16** So if you want to know how many people live within 10 minutes of a proposed movie theater location...

**36:22** ...or how many addresses don't have police coverage within 10 minutes...

**36:25** ...you'll do that with what we call the service area solver.

**36:28** Now this solver finds a region around a location or facility...

**36:31** ...that can be accessed within a specific cost or cutoff or...or break as we call it.

**36:36** Now with this solver, we use the term facility again like with the closest facility solver...

**36:40** ...but that means it's the location you're solving against, the...the area on the network that you're solving outward from.

**36:47** You can specify direction of travel again, like we could with the closest facility solver.

**36:51** So are you considering how customers will arrive at your store...

**36:54** ...or are you considering how far out from your store you can...you can service an area?

**36:59** Now there's also many polygon and polyline generation options as you see here...

**37:03** ...with polygons on the top and polylines on the bottom.

**37:06** The polylines show the streets that were covered within that break.

**37:09** The polygons are a generalized polygon around those covered streets.

**37:13** And sometimes they're called drive-time polygons.

**37:16** Now for scenarios with multiple facilities, the polygons or polylines can either overlap...

**37:22** ...as you see on the lines on the bottom right or you can have them stop when they hit each other...

**37:26** ...as with the service areas you see along the Eastern Seaboard of the United States there.

**37:31** It just depends on the type of problem you're trying to solve what's most appropriate.

**37:34** With service area, you can't generate directions because it's not point-to-point routing.

**37:39** You're driving out in every...in every direction, so it wouldn't make sense to print directions in that way.

**37:44** So Business Analyst was another application that they demonstrated at the plenary...

**37:48** ...and that uses service areas quite often to help businesses manage and analyze their data.

**37:54** This could be used to solve to find fire response zones or customer service areas, for example.

**38:02** Go through a demonstration of it.

**38:03** Now this is a map that I got from the Rancho Cucamonga, California, fire department...

**38:08** ...that they used to show that there was deficient fire coverage in the center of the city.

**38:12** They were tasked with the showing, finding any problems in the city with the fire engines reaching it.

**38:18** They have seven fire stations, six operational and one in the northwest corner that was being built...

**38:23** ...and they wanted to adhere to reaching every incident within four minutes, excluding the time leaving the station.

**38:30** So this map was created and presented to the Rancho Cucamonga City Council...

**38:33** ...as evidence that there's deficient fire coverage in this end of the city.

**38:36** And the council approved starting the process for building a new fire station because of it.

**38:40** So why did they choose to use service area for this kind of problem?

**38:44** The reason is, is that they wanted street coverage and they wanted visualization.

**38:48** They weren't trying to find the distance between individual points or sets of points...

**38:52** ...they weren't locating facilities or trying to figure out where to put the new fire station...

**38:56** ...and they weren't trying to route their fleet of engines.

**38:59** What they wanted was to clearly see the areas that weren't sufficiently covered.

**39:02** And that lends itself very well to the service area solver.

**39:10** So I got the addresses of the Rancho Cucamonga fire stations from their public Web site...

**39:14** ...and I created an empty service area layer.

**39:18** Here in the NA window you can see it.

**39:20** And I'll load these fire stations in as facilities by choosing to load, picking my fire stations, and loading them.

**39:29** So now my seven fire stations are...are loaded into my service area problem.

**39:33** And I click Solve...

**39:35** ...and it'll go through and figure out which streets are covered from these fire stations within four minutes...

**39:39** ...and generalize the polygon around that street coverage.

**39:42** And you can see that there is definitely a coverage hole in the center of the map here.

**39:46** It doesn't look exactly like their map because we have underlying street data.

**39:50** They might have different turn restrictions or one-way streets or even different speeds along the streets.

**39:56** So with the data I used with the free Data & Maps data, this was the hole that's generated in the coverage within four minutes.

**40:03** So the question now, because clearly, there's a problem, is how do you fix the problem?

**40:07** And we'll get to that when we talk about our next solver.

**40:12** So the takeaways from that demo are that you should first think about your problem type...

**40:17** ...and then decide on the appropriate type of analysis you want to do, the appropriate solver that you'll choose.

**40:22** In our case, it was coverage and visualization, and that's perfect for service area.

**40:27** Oh, yeah. And every time you see one of these intro slides in any of the presentations...

**40:32** ...there's service areas on that little strip up there.

**40:34** So you can thank the Network Analyst every time you go to any presentation for the rest of the UC.

**40:39** Except there's laser beams coming out of one of the service areas, and I'm not sure why that did that.

**40:46** Okay, so the next solver is the location-allocation solver.

**40:48** And this one's new at 10.0; we just came out with this one.

**40:51** The old cliché for real estate is there's three important things to consider, and that's location, location, and location.

**40:58** And in that case, this solver is your best choice.

**41:02** So it'll help you find where the optimum location is for a facility.

**41:06** The name of the solver breaks down what it does.

**41:07** It helps you locate facilities by allocating demand to those facilities.

**41:12** Now, we call them facilities like with the closest facility and the service area solver...

**41:16** ...but they're locations that you're asking the solver to pick from.

**41:19** They can be warehouses, bus stops, police stations, hardware stores...

**41:25** ...emergency vehicle predeployment areas, or whatever type of place you want to pick the best location for.

**41:30** Evacuation sites is another example I've seen.

**41:33** The other main input for the solver other than facilities is the demand points.

**41:37** Now these are the people or the things that require the goods or services that you're providing from your facility.

**41:43** This could be ZIP Code or census tract centroids.

**41:47** It could be business customers.

**41:48** It could be street intersections or whatever you want your facility to service.

**41:52** Now the demand points can be weighted for importance.

**41:55** Let's say the population in that ZIP code or census tract...

**41:59** ...or the expected consumption by consumers at that demand point.

[42:04](#) So remember also that this is all done along the network.

[42:06](#) These aren't straight-line distances; these are network paths.

[42:09](#) In the plenary, when they showed the location-allocation solver in Cleveland with the allocating for health facilities...

[42:17](#) ...it was based on travel along the road network, not just straight-line, crow-flies distances.

[42:22](#) This is a complex problem, so there's quite a few analysis types we offer, and they're listed here.

[42:27](#) There's minimize impedance and what that'll do is it'll solve to reduce the travel costs...

[42:32](#) ...from your customers to your location or from you to your customers.

[42:35](#) Now, this is good for locating warehouses, for example, to minimize the cost of transporting goods to your outlets.

[42:41](#) There's maximize coverage, which will solve to reach as many of the demand points as possible.

[42:46](#) An example of this usage might be locating fire stations...

[42:48](#) ...which might come in handy in our Rancho Cucamonga demo, or locating police stations to reach the most citizens.

[42:54](#) You just want to get out as much demand as possible.

[42:57](#) You can minimize the facilities...

[42:59](#) ...and what that'll do is it'll keep the...try to keep the demand you capture the same

[43:03](#) ...while reducing the number of facilities you use to do this.

[43:05](#) And it'll help you allocate your resources more efficiently, more cheaply.

[43:11](#) You can maximize attendance.

[43:13](#) And that will maximize coverage but take into account that demand might be reduced...

[43:18](#) ...the farther away somebody is from your facility.

[43:22](#) That'll help you adjust for demand you lost to your...

[43:24](#) ...your customer [sic], in case you don't have a lot of information about your competitors.

[43:28](#) The idea is that the further away somebody is in this type of problem, the less likely they are going to go to your facility.

[43:33](#) That could apply to grocery stores, especially.

[43:35](#) No one's going to travel a long way to go to your grocery store if there's a closer one.

[43:39](#) And you can maximize...maximize market share, and that'll get your facilities the most

demand...

**43:44** ...in the presence of competitor facilities.

**43:46** And that works well with large discount stores or something where you have a lot of information about your competitors.

**43:52** You can also target the market share.

**43:54** And that's like maximized market share, except you'll, instead of asking it...

**43:58** ...giving it a number of facilities you want to locate.

**44:00** You tell it the percentage market share you want, 12%, 97%, whatever problem you're trying to solve...

**44:05** ...and it will...the solver will determine the number of facilities you need in order to capture that level of market share.

**44:12** So we'll go back to Rancho Cucamonga here and try to solve their problem of fire coverage.

**44:21** So we're clearly aware that there's a problem in the center of Rancho Cucamonga; I'll zoom in to it.

**44:29** Turn on my location-allocation layer.

**44:33** So we're clearly aware there's a problem there, and the next step is to plug that hole in the coverage problem.

**44:38** Now how do we best solve this?

**44:39** We could just add locations one at a time by clicking and adding new facilities to the service area problem.

**44:45** And after a lot of effort, that might give us a pretty good guess, but it wouldn't give us the optimal location.

**44:51** For that, we should use the location-allocation solver; it's its job.

**44:54** So since I'm a smart GIS professional, I'm going to read the documentation and do the tutorials.

**45:00** And I can determine that the type of analysis that I want to do... Whoops. I'm on my service area problem.

**45:08** The type of analysis I want to do for location-allocation is maximize coverage, and that's the one I mentioned before...

**45:14** ...where you're trying to just get to as much demand as possible.

**45:16** And that makes sense for a fire engine because you're not preferring one set of customers over the other...

**45:20** ...and you're not less likely to serve people farther away.

**45:24** So choose Maximize Coverage.

**45:25** We know there's seven existing fire stations, and we want to add one more fire station to their...to their problem...

**45:31** ...so we set it up for eight facilities to choose.

**45:34** And we also set our impedance cutoff at four minutes just like our service area problem.

**45:38** Now I've loaded our seven fire stations in as required facilities.

**45:41** You can tell they're required by the little star...

**45:44** ...and that's a setting on the...on the solver, or on the properties of the location.

**45:48** And the next step is choosing which sites we want as our potential sites.

**45:52** In our case, there's plenty of public parks in this area...

**45:55** ...and that's a little bit easier for a city to take over than eminent domaining somebody's house...

**45:59** ...so we'll suggest these public parks as potential fire stations.

**46:03** So that's our first input.

**46:04** We've got our facilities.

**46:05** And the second set of inputs you need for location-allocation is demand points.

**46:10** In our case, we just want to reach out as far as possible from each of these fire stations.

**46:14** So I've set up points for every junction in the city.

**46:17** And it's easy data to get, and I can load those in as demand points to my location-allocation problem.

**46:22** And in our case, there's 9,129 demand points.

**46:26** And you can see all these potential sites are loaded in...

**46:29** ...and they don't have a star in them, meaning that they're candidate locations.

**46:33** So I can click Solve, and the location-allocation solver will quickly go through...

**46:37** ...out of these 19 facilities and nearly 10,000 demand points...

**46:40** ...and tell us which of these facilities is...best serves to allocate to these demand points.

**46:46** Yes, sir.

**46:47** [Audience question] Your demand points are entered as such as all the intersections? Is that what it was?

**46:51** Yes. I picked every junction in the city.

**46:53** Because it's easy data to get out of a network dataset...

**46:55** ...especially because there's your edge source, which is your streets, and there's a junction source, which is your intersections.

**47:01** But you can use anything for your demand points.

**47:03** You might want to use buildings or population information.

**47:07** And I'm...

**47:08** [Audience question] It was a dataset that was very convenient.

**47:10** Yeah. And it also...I bet Rancho Cucamonga probably would've used incidents, used some historical incident data...

**47:16** ...but I don't have their data, so I went with easily available data.

**47:20** [Audience question] Excuse me. One question.

**47:21** Sure. [Audience question] Is there anything...I noticed there's some gaps there...

**47:23** Um-hmm.

**47:24** [Audience question] ...[unintelligible] bottom middle screen.

**47:26** Down here? [Audience question] Yeah. Is there any way to force those two points to meet?

**47:31** You mean with these...

**47:32** [Audience question] With your junctions.

**47:34** [Audience question] You see, you've got a gap between those two junctions...

**47:37** [Audience question] ...because the street between the junction points is not covered.

**47:41** I'm not quite sure which area you're talking about...

**47:42** Oh, he's using the junctions instead of the streets.

**47:45** So he could use street centroids instead.

**47:47** That might be why.

**47:51** Oh, yeah, this is just as you see, each intersection.

**47:53** You can see especially in this slide that it's just the intersections that were chosen as demand points.

**47:58** Or it's street centroids with junctions.

**47:59** [Audience question] Do you use the parcel, [unintelligible] parcel?

**48:01** Sure. Yep.

**48:02** That would've worked. Let's say you couldn't get centroids for all the parcels and try to reach every parcel as well.

**48:06** And that would probably be more accurate too, 'cause you'd get a guess on exactly where they would be dispatched to.

**48:11** And perhaps you could weight them by the...the population at those centers.

**48:16** So you can see here that the location-allocation chose...

**48:21** ...the southwest corner of Rancho Cucamonga Central Park, which makes sense; it's centralized there.

**48:25** And it put a little star in it meaning it was chosen as our one extra facility.

**48:29** So just to show, I will copy that facility...

**48:34** ...into our service area problem, and re-solve our problem, and we'll see if it...if it plugs that hole in the coverage.

**48:42** So it'll take a second again to solve outward from each of these facilities, eight now...

**48:47** ...and to generalize these polygons around the facilities.

**48:49** And you can see that it covers this area in the middle.

**48:51** There's a little issue here because it doesn't quite cover across this...this park.

**48:55** So that could be fixed by streets or however they were going to do it.

**49:02** So for locating the fire stations...yes, sir?

**49:05** [Inaudible audience question]

**49:13** Your question was, What is the output of a location-allocation problem?

**49:16** [Inaudible audience question]

**49:25** Right. So the question is what kind of output would we have and is distance included. Yeah.

**49:31** There is several parts, or several components to the output.

**49:35** So one of the pieces of the component are the chosen facilities.

**49:38** Another piece is the...how much demand is allocated to the facilities, or which demand in this case is allocated to the facility.

**49:46** And it will also give you the cost of traveling from the facility to the demand point as well.

**49:54** You can get that information.

**49:55** So each of these lines contain the network cost to travel from each of those demand points to the facility.

**50:01** As we said, it's not as the crow flies, the Euclidean cost.

**50:04** It's the cost of traveling along that network.

**50:07** The lines just demonstrate that there's an association between that chosen facility and the...

**50:10** ...and the point you used as a demand point.

**50:16** [Inaudible audience question]

**50:17** Sure.

**50:18** [Inaudible audience question]

**50:25** Yes. Yes.

**50:27** This was simplified just to reach as far as you can within four minutes.

**50:30** Or as many demand points as possible...

**50:32** Yeah. Within four minutes.

**50:33** And Rancho Cucamonga is an interesting problem, because there's a big mall on this side of the city.

**50:38** So they would really want to weight demand more if they...if they truly were doing this analysis to...

**50:42** Right. It sounds like the question is do we solve capacitated location-allocation.

**50:46** And, no, we don't have capacitated allocation right now, location-allocation right now.

**50:51** [Audience question] You don't. Do you want to define capacitated location-allocation for everybody?

**50:54** Capacitated location-allocation is where you assign a particular number of demand points to a facility...

**50:59** ...and here, we're just making sure that we have a coverage of four minutes to reach all our demand points.

**51:05** And we don't really care how many demand points are covered within that four minutes, just as long as they're covered.

**51:12** [Audience question] Okay. But you could use capacity to solve your other options using the location-allocation method, right?

**51:22** You can weight the demand points themselves, yes.

**51:24** [Audience question] Yeah. Yeah. So it was about the school application or, you know, you would set [unintelligible]...

**51:29** [Audience question] ...how many children could go to school for public health centers or so? You use that?

**51:36** Not out of the box, per se.

**51:38** But if you attend the...what's the one Deelesh is giving?

**51:41** Is it Automating Workflows with Geoprocessing?

**51:43** Yeah. He has some geoprocessing tools that allow you to do...answer that type of question.

**51:47** So what it'll do is it'll get the results of an OD cost matrix and export that into...

**51:54** ...can use the results in a linear programming application and then have that run.

**51:59** It uses Python, PuLP linear programming.

**52:02** And he does a school allocation problem.

**52:04** And that we have a script that'll do school allocation using the...one of our other solvers that we haven't gotten to yet...

**52:09** ...the OD cost matrix and a linear programming package together to do it.

**52:12** [Audience question] Okay.

**52:16** So the takeaways from this are that, again, you want to think about the problem type you're solving...

**52:21** ...and then pick the solver most appropriate for it.

**52:23** In our case, we were locating a facility, so it made sense to use location-allocation.

**52:28** And we also used the correct analysis type out of there for maximized coverage, just to find the...

**52:33** ...the coverage we could reach from our fire station.

**52:38** So our next solver is the vehicle routing problem solver.

**52:41** Now this will help you determine how best to assign a group of customers to a fleet of vehicles...

**52:47** ...as well as sequencing and scheduling the visits to those locations.

**52:51** This is often used for distribution, for inspectors, for assessors, for technicians, for paratransit.

**52:58** Now, there's many input classes for this solver, but there's three that you need to know to get started, the first one being orders.

**53:04** Now, these are the places you want your vehicles to visit.

**53:06** They could be orders, as they're called...

**53:08** ...they can be inspection sites, they could be people you want to pick up and drop off.

**53:12** Now the depots is the second one.

**53:14** That's the starting and ending points of your routes.

**53:17** That could be warehouses where you pick up the cargo.

**53:19** It could be bus depots, et cetera.

**53:21** And the third is routes.

**53:23** Now, these are the separate routes you want created.

**53:25** It's generally used to represent vehicles.

**53:27** If you have five trucks, you'll use...set up five routes within your vehicle routing problem solver.

**53:32** But it could be...also be days.

**53:33** For example, if you have one truck and you just want to set up your orders throughout a week...

**53:37** ...you can set it up to do Monday, Tuesday, Wednesday, Thursday, Friday, and it'll allocate the orders optimally for you.

**53:44** So VRP will help you generate high customer service, because it'll honor time windows like with the routing problem solver...

**53:49** ...and it'll keep your overall operating and investment costs for the fleet to a minimum.

**53:54** Remember, shorter routes, optimized routes equal less gas, less tri...

**53:58** ...time driving, so less driver overtime, more customers reached for cheaper.

**54:04** ArcLogistics is a product that was mentioned at the plenary as well.

**54:07** That's an Esri product that's a stand-alone application built upon the vehicle routing problem solver.

**54:12** Now it's a fleet routing solution that's meant to be easy for dispatchers instead of GIS professionals.

**54:18** So, and it's also one of the pioneers in cloud computing and Software plus Services.

**54:22** And it can save up to 30 percent in fleet-related costs just by optimizing these routes.

**54:27** There's many possibilities as you have fleets of vehicles and can think of routes.

**54:31** So Bob will give you a demonstration of appliance delivery using the vehicle routing problem solver.

**54:35** Okay. For this demonstration, the study area is Indianapolis...

**54:39** ...and I have an appliance store that's represented by that square in the middle of the map.

**54:44** And each day, customers come in and they purchase appliances.

**54:48** So I need to deliver the appliances and install them in their house.

**54:52** So these are the deliveries I need to make today, represented by the circles...

**54:58** ...and I have a fleet of four vehicles to make the deliveries.

**55:02** So what I'm going to do is create a vehicle routing problem, and first I'm going to load my depot, which is the store.

**55:10** That's where my vehicles start and end their route each day.

**55:13** We can also have vehicles start and end from two different locations if we wanted.

**55:22** So I'll load my appliance store as the depot, and I'm going to turn off some of these other layers.

**55:31** I'll turn off the customers of the appliance store for now.

**55:34** Next I want to load the information about my trucks, and I load those into routes.

**55:38** And just think of routes as representing trucks or drivers, because the drivers drive the trucks along the routes.

**55:47** And here's my vehicle information that I'm loading.

**55:50** I have four vehicles.

**55:51** We can take a look at that information.

**55:52** There's lots of properties we can model.

**55:56** So here's the depot that the vehicle starts from, that it ends at.

**56:00** And one of the properties I want to point out is the capacities.

**56:04** This is how much the vehicle can carry and I've chosen to have it represent cubic feet.

**56:10** So 1,250 cubic feet is its capacity.

**56:13** I could also use weight, you know, volume and weight together.

**56:18** I could have multiple combinations.

**56:20** I could use number of people if I'm transporting people or number of units.

**56:26** So there's a lot of flexibility there.

**56:28** And my drivers should only be on duty for nine hours, so I've set the max total travel time, or max total time to 540.

**56:37** So that's nine hours.

**56:40** And now I'm going to load my customers as orders, because the customers make orders.

**56:49** And we'll take a look.

**56:50** Most of these customers can make themselves available when I say that I'm going to be there

at their house...

**56:55** ...but some of them are only available at a certain time during the day.

**56:59** So if we take a look at customer 1226, we see that they're only available between 1:00 p.m. and 3:00 p.m.

**57:08** So I want the VRP solver to tell me, give me some routes that I...so that I can reach this customer within that time range.

**57:16** Also, notice that they have the delivery quantities here.

**57:18** This is the size of the appliances that are going to be delivered.

**57:22** So this is paired up with the capacities of the routes...

**57:25** ...and this is how the VRP solver will make sure that my trucks don't become overloaded.

**57:34** Okay. One other thing I want to include here are the breaks for my drivers.

**57:38** They're allowed to take a 30-minute lunch break.

**57:42** So I've got information about the driver breaks here.

**57:47** And notice that I have one break for each truck.

**57:51** Open up the properties of the break, and I've given a time window of 11:30 a.m. to 12:30 p.m.  
...

**57:57** ...and what that means is the break can start sometime between that time range.

**58:03** And the service time is 30 minutes so that means that they're allowed 30 minutes for their lunch.

**58:10** And I just need to go in here and set a cost attribute.

**58:14** And now I'll go ahead and solve the analysis.

**58:18** And what it's doing, it's assigning orders to the different vehicles and then it's sequencing those orders in an optimal way...

**58:26** ...and it's also giving consideration for those time windows that I had on some of my orders.

**58:31** And these are the routes.

**58:34** We look at the Network Analyst window, we see that the orders are now categorized by the truck that they're assigned to.

**58:42** And this is the same customer I showed you a moment ago where he had the time window of...

**58:47** ...1:00 p.m. to 3:00 p.m. when he was available.

**58:49** And we'll take a look to see what time it arrives, and we see that it arrives within the time

window at 1:39 p.m.

**58:58** Now I like to visualize my results a little better...

**59:01** ...so what I'm going to use is the new Search window to find the Apply Symbology From Layer tool.

**59:11** And what this will do is take some symbology that I've defined for another vehicle routing problem analysis...

**59:17** ...assuming that I assign this each day, I...I create new routes for my...

**59:23** ...for my trucks, so that what I can do is just assign that symbology to my vehicle routing problem.

**59:30** So that symbology is stored on disk here.

**59:33** And I'll run the tool.

**59:35** Here it's a little easier to cleave out the different routes.

**59:39** And we can see they're color coded.

**59:42** And what I can do is generate directions just like I did for the routes...

**59:46** ...and to print these off or distribute them to my drivers electronically.

**59:51** Okay. So the main things that I wanted you to take away from that is that if you need to route several vehicles to visit many locations...

**59:58** ...either for inspections, visiting clients, pickups, deliveries, mixed pickup and delivery...

**1:00:04** ...the vehicle routing problem will help you create optimal routes for...for them.

**1:00:09** And it will help you reduce labor costs, fuel and maintenance costs, as well as carbon emissions.

**1:00:16** And time windows will help you maintain a high level of customer service.

**1:00:22** And lastly, remember that we have ArcLogistics available, both...

**1:00:27** ...there's also an online version that you can use of that and give it a try.

**1:00:32** And it's just another application that's based off this vehicle routing problem, and it's geared towards non-GIS professionals.

**1:00:40** Give me a switch?

**1:00:42** Okay.

**1:00:43** Yes?

**1:00:44** [Audience question] If you had school buses, and you were trying to route the school buses, elementary, this and that...

**1:00:49** [Audience question]...and you have [unintelligible] at beginning of the year, would you use this tool to do that?

**1:00:53** Yes. So the question is, Can you use VRP to solve school bus routing problems...

**1:00:58** ...and I would say with a cautious yes, I guess.

**1:01:02** You can do the main parts.

**1:01:04** I used to be a school bus-...school bus dispatcher, and you can...

**1:01:09** ...you can generate the routes, and you can get good routes quality.

**1:01:11** [Inaudible audience question]

**1:01:14** Right. But if you want more information, like a lot of these school bus routing programs will have information about students.

**1:01:22** So like you have a substitute driver, they'll have a picture and information about the student and...

**1:01:26** ...verify they're picking up the right child.

**1:01:30** So it wouldn't do that type of stuff out...out of the box, of course.

**1:01:33** But we also have a business partner, RouteSmart, and I think they have a...a...a booth downstairs, that they provide...

**1:01:41** It is RouteSmart, right? I think...

**1:01:43** Do school bus routing?

**1:01:44** Yeah. They do the snowplow and garbage truck.

**1:01:46** Do they do school bus as well?

**1:01:48** Yeah, so they might be able to provide you some more like a specialized product for school bus routing.

**1:01:54** Okay. You're welcome.

**1:01:57** Our sixth and final solver is the origin-destination cost matrix solver.

**1:02:01** And who here has seen the time and distance tables that you see in a route atlas or a road atlas?

**1:02:07** So that's basically what the OD solver generates, and we call this the OD solver, the origin-destination cost matrix solver.

**1:02:14** It sounds intimidating, but it's not.

**1:02:16** Instead, it makes simply a table or a matrix of the cost to travel from one location in a set of locations...

**1:02:23** ...to all the other locations in another set of locations.

**1:02:27** So you could use this to solve logistical problems like finding all the distances from all the distribution facilities...

**1:02:32** ...to each warehouse facility.

**1:02:34** You could use it to export out the results to a linear programming package to do things like school-student allocation...

**1:02:40** ...which we have a script that does.

**1:02:43** And internally, we use it to optimize the stops in...in the VRP solver, the vehicle routing problem solver...

**1:02:48** ...as well as the traveling sales problem...salesman problem done by the route solver.

**1:02:52** Many of our clients use OD for their own TSP and VRP problems as well.

**1:02:57** I've also seen this used to help manage firefighter response times, with concern for the fire stations and evacuation sites.

**1:03:03** It also helps to validate historical incident response times.

**1:03:07** And notice the lines you see connecting the origins and the destinations.

**1:03:11** Like with the location-allocation solver, these lines don't demonstrate that the path found was a straight line.

**1:03:17** It's still a network cost path.

**1:03:18** The line just shows that there's an association between one stop and the other one.

**1:03:27** So here we have a pretty map of the United States as a basemap...

**1:03:31** ...and underneath it I have the free Data & Maps data that comes with the Data & Maps DVD.

**1:03:37** This is the read-only SDC data as we call it, or StreetMap data.

**1:03:41** So I've put in all 50 state capitals into an OD problem and solved it.

**1:03:46** And what's generated is a set of 2,500 lines showing associations between 50 state capitals.

**1:03:53** Oh, and there's no Honolulu, and Washington, D.C., has been added.

**1:03:56** That's how it comes up to 50.

**1:03:59** So with this OD solver, you do the solve.

**1:04:02** And the real power of OD isn't in these lines; it isn't in symbology that you see there.

**1:04:06** It's in this table that's generated...

**1:04:08** ...this table of costs from each origin in the 50 origins to every destination in the 50

destinations.

**1:04:16** And this can be used for data mining purposes or however you'd use big groups of data like this.

**1:04:22** And I also want you to notice that...that the OD solver and the closest facility solver are very similar; they solve similar analysis.

**1:04:29** M by n problems we call it, with two sets of inputs.

**1:04:32** The difference is OD doesn't generate geometry; it just gives you lines...

**1:04:36** ...where the closest facility solver will give you route geometries.

**1:04:39** So this solver is much faster because of that.

**1:04:46** So if you want to solve big problems, you don't care about the route geometries, then the OD solver is the one to go for.

**1:04:51** It also has time cutoffs and number cutoffs if you want.

**1:04:55** For example, here's a problem of the 50 origins to 50 destinations where you only find the nearest four destinations from every origin.

**1:05:05** Which, by the way, includes itself, because each of these capitals are in both sets of inputs.

**1:05:15** Go back here.

**1:05:20** So the important thing to think of with the OD solver...yes, sir.

**1:05:23** [Audience question] I want to know long it took to generate that [unintelligible]?

**1:05:28** It's pretty quick.

**1:05:30** I didn't do it because just to save time as we're running here at the end. You can see...

**1:05:36** ...[Inaudible audience question]

**1:05:37** Oh, yeah. Less than...less than 20 seconds, I would think.

**1:05:41** Less than 30 seconds maybe.

**1:05:42** So it ran through all the destinations and did a backward search...

**1:05:45** ...and now it's going through all the origins and finding the distance to each destination.

**1:05:49** So you could see it's tootling along there.

**1:05:51** I did it for...

**1:05:52** [Audience question] It's using the underlying map for all this.

**1:05:55** Yes. It's using its...everything's done along the roads.

**1:05:58** This is an entire country worth of streets that it's solving from every origin to every...

**1:06:03** ...every destination in...in just a few seconds really.

**1:06:08** There it goes. We'll let it finish up.

**1:06:11** Three, two, one...yay! There it goes. Okay.

**1:06:16** So the important thing, though, is with the...

**1:06:17** ...with the closest facility solver, that would've been very difficult because of the route geometries.

**1:06:21** And it would have to maintain internally 2,500 tremendously long routes.

**1:06:27** So you...for this type of problem, you'd want to use the origin-destination cost matrix solver.

**1:06:32** So as a summary of the presentation, I want to just go over the benefits of Network Analyst.

**1:06:37** First and foremost is the accuracy of the transportation model, which is the network dataset model that you saw demonstrated.

**1:06:43** And if you have a good accurate model, you should be able to solve your transportation problems fairly quickly...

**1:06:49** ...and, in doing so, optimizing your routes and saving the company money.

**1:06:52** And you can also save the company money by putting facilities in the right place.

**1:06:56** I've seen examples of people locating facilities along...

**1:06:59** ...where they think they're near a freeway because they have a straight-line distance to the freeway...

**1:07:03** ...when really, they're far away from the onramp.

**1:07:05** Because what you need to worry about is your transportation network as your distances, and not just straight-line distances.

**1:07:12** Also, we showed you Network Analyst on the desktop as well as in ArcGIS Server.

**1:07:16** And a little bit of geoprocessing.

**1:07:18** But you can do everything we did through geoprocessing and everything you do with Network Analyst through geoprocessing.

**1:07:22** There's also out-of-the-box controls if you want to write your own ArcGIS Engine application for Network Analyst.

**1:07:28** And there's a few common questions we get, and I should've put school bus routing on this...

**1:07:33** ...'cause that's one of the common questions we get as well.

**1:07:35** There's something called high-density routing or arc routing, where you're not routing to points; you're routing to entire streets...

**1:07:42** ...like with garbage collection or snowplows.

**1:07:44** And in that case, Network Analyst doesn't support it out of the box because it's a different type of algorithm.

**1:07:50** You don't want your snowplow going back across streets it's already covered, for example.

**1:07:53** So you can...you can work it out, but we don't handle it out of the box.

**1:07:57** And RouteSmart is one of our business partners that does do that, built upon our software.

**1:08:02** We're also asked often if you can get alternative shortest paths.

**1:08:06** I found one path; I want to know the next three shortest paths.

**1:08:08** And there's definitely ways to do that.

**1:08:10** There isn't a solver out of the box, but there's scripts available online that do it.

**1:08:14** If you're interested in utility or natural resource networks, as I mentioned in the beginning, what you want is geometric networks.

**1:08:20** And that's covered elsewhere in ArcGIS.

**1:08:22** And they just ended a presentation, but there's another one, I believe, tomorrow at 3:15.

**1:08:26** I have a slide that'll show that.

**1:08:28** Transit schedules is another common question that we get.

**1:08:31** We do work with multimodal networks...

**1:08:32** ...where you can have bus lines connected to streets connected to bike paths.

**1:08:37** But we don't work with is transit schedules.

**1:08:39** In our case, you would get off your car, get on the bus and go...

**1:08:42** ...where a transit schedule would want you to wait for half an hour for the next bus to arrive or something like that.

**1:08:49** So now, for the rest of the Users Conference, if you're interested in learning more about Network Analyst...

**1:08:54** ...I've handed out little small flyers that have some schedules of when all these tech workshops are and when our demo theaters are.

**1:09:01** We highly recommend you come down to the Spatial Analyst Island if you have any questions for us.

**1:09:06** There's developers there and more product engineers, and we'd love to talk with our clients and get feedback...

**1:09:11** ...our users I guess as we say.

**1:09:14** And so the next step you'd want to do is Performing Network Analysis, and that'll be in room 9.

**1:09:18** And there Jay and Deelesh will help you choose your solver and tweak the settings to tweak the algorithms that the solvers use.

**1:09:27** If you're working with your own data, I highly recommend the Creating Network Datasets session.

**1:09:31** Alan will help you walk through the creation and build process.

**1:09:34** I believe he does it with TIGER data.

**1:09:37** By then, you'll start automating your efforts because you'll be an expert, so you want to do that using geoprocessing in Server.

**1:09:42** And Deelesh will walk you through automating your efforts in that way.

**1:09:47** There's quite a few demo theaters as well.

**1:09:48** Don't worry about getting all this down; they're all written on the little half sheet.

**1:09:52** And they're all at the Spatial Analyst Demo Theater, which is right next to our Spatial Analyst Island.

**1:09:59** There's a VRP-specific demonstration if that's what you're interested in, and that's...that's at 10:00 a.m., so next.

**1:10:05** There's also a real-time routing... He uses VRP as well on Server, if you're interested in that.

**1:10:10** And the purple box is on the Server Island.

**1:10:13** There's also a location-allocation-specific demo tomorrow afternoon and a 3D-specific demo as well tomorrow...

**1:10:19** ...if that's what you're interested in.

**1:10:21** Also, I forgot to mention at the beginning, you have two surveys.

**1:10:24** Sorry if it's a little confusing.

**1:10:25** There's the survey for this presentation, which we really appreciate you filling out and giving us feedback.

**1:10:30** And those are the ones you drop in the little box outside.

**1:10:32** And there's the survey about Network Analyst.

**1:10:34** And I appreciate you filling that out as well.

**1:10:36** And you can just leave that on your chairs and I'll collect those at the end, because it's a separate process.

**1:10:43** There's some ArcLogistics sessions if that's what you're interested in attending, and they're

in the Mezzanine Level.

**1:10:48** And those are listed in your book as well.

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