



Audio Engine: Router Concepts 101

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Introduction

While the use of central signal routers is fairly new to radio broadcasters, routers have been the backbone of television facilities for decades. As the broadcast radio industry makes its conversion to the digital domain, most engineers are discovering that most, if not all, of the digital console systems being offered by vendors are router based. It is with this in mind, and with no intent of insulting the intelligence of any readers, that this basic primer in the concepts of audio signal routers is presented.

Routers: What are they?

Whether you pronounce it “router” or “rowter” (both are correct, by the way), a router is a fairly simple idea. Let’s begin by looking at the definition of the root (no pun intended) word: route.

Route:

- n: A road, course, or way for travel from one place to another
- v: To send or forward by a specific path.

Well, that explains everything! A router is simply a device for getting a signal from one place to another.

As an example let’s take a look at a small router with 2 inputs (IN-1 and IN-2) and 2 outputs (OUT-A and OUT-B). Now is also a good time to introduce additional terminology that is in common use when talking about routers: **sources** (inputs) and **destinations** (outputs).

	OUT-A	OUT-B
IN-1		
IN-2		

Figure 1: A simple routing matrix

Figure 1 is a typical matrix – listing the **sources** vertically on the left and the **destinations** horizontally across the top. This simple router offers us several possible **source-to-destination**, or routing, combinations.

	OUT-A	OUT-B
IN-1	✓	
IN-2		✓

Figure 2: One possible routing combination.

Figure 2 represents a typical “default” route. Input-1 is sent to Output A while Input-2 is sent to Output-B.

	OUT-A	OUT-B
IN-1		✓
IN-2	✓	

Figure 3: A second possible routing combination.

In Figure 3 the route sends Input-1 to Output-B and Input-2 to Output-A. A simple “output swap” if you will.

	OUT-A	OUT-B
IN-1	✓	✓
IN-2		

Figure 4: A third possible routing combination.

Figure 4 illustrates one of the powerful benefits of routing systems: the ability to send one **source** to multiple **destinations** without the need for distribution amplifiers.

	OUT-A	OUT-B
IN-1		
IN-2	✓	✓

Figure 5: A fourth possible routing combination.

This final route exhausts the available combinations in this small and extremely limited router. But before we leave this example let’s plug in some real-world names that might help clarify how this router might be used.

	Transmitter-A	Transmitter-B
Studio-1 Program	✓	
Studio-2 Program		✓

Figure 6: A real-world application.

You can see now how easy it will be to swap the Studio outputs between the two transmitters – or to put a single Studio on both transmitters. You can easily envision this diagram as representing a small patch-bay – with the “✓” in the box representing the patch-cord. One end of the patch cord connects to the source and the other end to the destination.

Of course, in the real world you wouldn’t have a router this small. So let’s expand things a little bit and look at a router matrix that might be a little more useful!

Routers: A Real-World Application

In the real-world of radio broadcasting we deal with multiple sources and multiple destinations every day. In today's business environment of central-casting, multi-casting, web-streaming, satellite distribution and the newly expanding wireless marketplace the need for a central routing system becomes more and more critical.

For the moment, we'll limit ourselves to dealing with simple point-to-point routing – but we'll get more detailed a little later on.

	KAAA TX	KAAA WEB	KBBB TX	KBBB WEB	KCCC TX	KCCC WEB	KDDD TX	KDDD WEB	RECORD PC
Control Room 1 PGM	✓	✓							
Control Room 2 PGM			✓	✓					
Control Room 3 PGM					✓	✓			
Control Room 4 PGM							✓	✓	
Production Room									✓

Figure 7: A Centralcasting Facility Matrix.

Figure 7 illustrates a common usage of a central routing system. A central facility houses multiple control rooms and sends those outputs to multiple transmitters each with an associated webstream. The routing shown above might represent the normal “default” setup: KAAA usually originates in Control Room 1, KBBB in Control Room 2, and so on. Once again, you can see how easy it is to send a single source to multiple destinations – as each Control Room's program bus is feeding both the transmitter and the webstream. The production room's default routing is to a PC for recording and later editing.

One of the greatest benefits of a routing system like this is flexibility for the facility. Let's assume that this facility is a 24/7/365 talk-radio broadcaster and Engineering needs to take Control Room 3 down for maintenance. By simply routing the Production Room to the KCCC transmitter and webstream, the on-air programming can continue without interruption while you clean the coffee spill out of the board in Control Room 3.

See Figure 8 on next page.

	KAAA TX	KAAA WEB	KBBB TX	KBBB WEB	KCCC TX	KCCC WEB	KDDD TX	KDDD WEB	RECORD PC
Control Room 1 PGM	✓	✓							
Control Room 2 PGM			✓	✓					
Control Room 3 PGM	maintenance								
Control Room 4 PGM							✓	✓	
Production Room					✓	✓			

Figure 8: Temporary routing for maintenance in Ctrl. Rm. 3.

Of course, for this to really work in the real-world, all of the production sources (mics, CD Players, Mini-disks, Hybrids, etc.) that Control Room 3 uses on a daily basis must be made available to the Production Room as well. That way the on-air staff of KCCC can produce their program as usual even though they are not in their usual control room. A central routing system makes this very easy to do. But before we delve into the explanation of that - we need to explain how audio consoles work in a router-based system.

Router-based Audio Consoles

In the old days....pre-router days, that is....the console was the heart of the audio system. It contained all of the hardware for processing and mixing the audio signals. This meant that all devices were 'hard-wired' to the console. If a device needed to be shared between two consoles a distribution amplifier was required and the outputs of the DA were 'hard-wired' to both consoles.

Today's consoles do not have the processing and mixing hardware physically inside them. They are simply control surfaces that communicate to the processing and mixing hardware that is physically located in the central routing system. Audio processing, like many other fields, has been transformed by the microchip. Digital Signal Processors, or DSP chips, have reduced the physical hardware of the old analog processors and mixers that used to occupy the majority of the space in those large multi-channel consoles down to a single computer chip.

These DSP chips are, in fact, digital mixers. Therefore, they have their own sets of inputs and outputs. As an example, let's look at a small DSP input / output matrix for Control Room 1 from Figures 7 & 8.

See Figure 9 on next page.

		Router Destinations							
		KAAA TX							
Router Sources	DSP Destinations	DSP Sources							
		PGM OUT	STUDIO OUT	MONITOR OUT	HEADPHONES	AUX-1 OUT	AUX-2 OUT	AUX-3 OUT	CUE OUT
	Host Mic	Fader 1 In							
	Guest Mic 1	Fader 2 In							
	Guest Mic 2	Fader 3 In							
	Phone Hybrid	Fader 4 In							
	CD Player	Fader 5 In							
	MiniDisk	Fader 6 In							

Figure 9: A DSP input/output matrix.

This may create some confusion at first glance. But let's look at what is going on here. The blue-shaded section is the router itself. The pink shaded area is the DSP card. The router **sources** (mics, hybrid, CD and MD) have been routed to **DSP Destinations** (the fader inputs) and the **DSP Source** (PGM OUT) has been routed to a router **destination**. What makes this confusing to look at is the fact that we have reversed the positions of the sources and destinations in the DSP matrix. So let's change that and use our standard orientation, **sources** listed vertically on the left and **destinations** horizontally across the top, to make it easier to understand. *It is also helpful to think of the DSP card as an "external device" even though it is physically located in the same mainframe as the rest of the routing system.*

	KAAA TX	KAAA WEB	KBBB TX	KBBB WEB	KCCC TX	KCCC WEB	KDDD TX	KDDD WEB	RECORD PC	DSP FADER 1 IN	DSP FADER 2 IN	DSP FADER 3 IN	DSP FADER 4 IN	DSP FADER 5 IN	DSP FADER 6 IN
Host Mic															
Guest Mic 1															
Guest Mic 2															
Phone Hybrid															
CD Player															
MiniDisk															
DSP PROGRAM OUT															
DSP STUDIO OUT															
DSP MONITOR OUT															
DSP HEADPHONES OUT															
DSP AUX-1 OUT															
DSP AUX=2 OUT															
DSP AUX-3 OUT															
DSP CUE OUT															

Figure 10: Standard matrix layout showing Router Ins & Outs (blue) and DSP sources & destinations (pink).

Let's take a look at one source, the Host Mic, and see how we might be able to route it through the system. First, we could route the microphone directly to the transmitter and the webstream.

	KAAA TX	KAAA WEB	KBBB TX	KBBB WEB	KCCC TX	KCCC WEB	KDDD TX	KDDD WEB	RECORD PC	DSP FADER 1 IN	DSP FADER 2 IN	DSP FADER 3 IN	DSP FADER 4 IN	DSP FADER 5 IN	DSP FADER 6 IN
Host Mic	✓	✓													
Guest Mic 1															
Guest Mic 2															
Phone Hybrid															
CD Player															
MiniDisk															
DSP PROGRAM OUT															
DSP STUDIO OUT															
DSP MONITOR OUT															
DSP HEADPHONES OUT															
DSP AUX-1 OUT															
DSP AUX=2 OUT															
DSP AUX-3 OUT															
DSP CUE OUT															

Figure 11: Standard matrix layout showing Host Mic routed directly to the transmitter.

But that wouldn't give us any control over the microphone levels – or the ability to turn it on and off easily. That's what the audio console is for! So, to give us those controls over the microphone, we route the Host Mic to one of the faders on the DSP card – then take one of the DSP outputs, perhaps Program Out, and route IT to the transmitter and webstream. Like this:

	KAAA TX	KAAA WEB	KBBB TX	KBBB WEB	KCCC TX	KCCC WEB	KDDD TX	KDDD WEB	RECORD PC	DSP FADER 1 IN	DSP FADER 2 IN	DSP FADER 3 IN	DSP FADER 4 IN	DSP FADER 5 IN	DSP FADER 6 IN
Host Mic										✓					
Guest Mic 1															
Guest Mic 2															
Phone Hybrid															
CD Player															
MiniDisk															
DSP PROGRAM OUT	✓	✓													
DSP STUDIO OUT															
DSP MONITOR OUT															
DSP HEADPHONES OUT															
DSP AUX-1 OUT															
DSP AUX=2 OUT															
DSP AUX-3 OUT															
DSP CUE OUT															

Figure 12: Standard matrix layout showing Host Mic routed to a fader input on the DSP card and the Program out from the DSP card routed to the transmitter.

Now let's route the rest of the microphones, the hybrid, CD and MiniDisk players.

	KAAA TX	KAAA WEB	KBBB TX	KBBB WEB	KCCC TX	KCCC WEB	KDDD TX	KDDD WEB	RECORD PC	DSP FADER 1 IN	DSP FADER 2 IN	DSP FADER 3 IN	DSP FADER 4 IN	DSP FADER 5 IN	DSP FADER 6 IN
Host Mic										✓					
Guest Mic 1											✓				
Guest Mic 2												✓			
Phone Hybrid													✓		
CD Player														✓	
MiniDisk															✓
DSP PROGRAM OUT	✓	✓													
DSP STUDIO OUT															
DSP MONITOR OUT															
DSP HEADPHONES OUT															
DSP AUX-1 OUT															
DSP AUX-2 OUT															
DSP AUX-3 OUT															
DSP CUE OUT															

Figure 13: Standard matrix layout showing all control room devices routed to DSP fader inputs. DSP Program Out includes all DSP Fader inputs added to program bus.

Now we have all of our production devices assigned to faders on the control surface and the program output being sent to the transmitter and the web. We are in business! Of course, this is a highly simplified setup. But all of the other requirements for a studio – multiple mix-minus busses, aux-busses, monitor feeds, headphone feeds, cue channels, sub-mixers, etc., etc. – are simply additional DSP outputs! By routing the desired **Router Sources** from the router into the proper **DSP Destinations** and then routing the desired **DSP Sources** to the desired **Router Destinations** we can easily construct a matrix as simple or complex as we may require.

Conclusion

This brief introduction into digital audio router concepts is just that – an introduction. Once one has grasped these basic concepts it becomes easier to visualize new ways that a router system can benefit a facility. Sharing resources between studios, bypassing equipment for maintenance or building complex inter-studio intercom systems – all of these and more are made not only possible – but easy to accomplish with a central routing system.

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