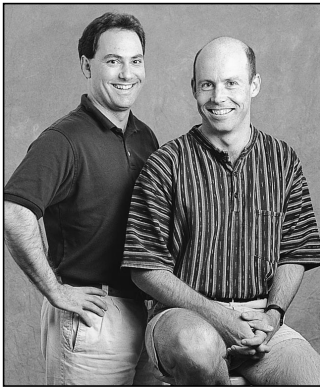

The Speech Recognition Manager Revealed

As any Star Trek fan knows, the computer of the future will talk and listen. Macintosh computers have already been talking for a decade, using speech synthesis technologies such as MacinTalk or the Speech Synthesis Manager. Now any Power Macintosh application can use Apple's new Speech Recognition Manager to recognize and respond to spoken commands as well. We'll show you how easy it is to add speech recognition to your application.



**MATT PALLAKOFF AND
ARLO REEVES**

Speech recognition technology has improved significantly in the last few years. It may still be a long while before you'll be able to carry on arbitrary conversations with your computer. But if you understand the capabilities and limitations of the new Speech Recognition Manager, you'll find it easy to create speech recognition applications that are fast, accurate, and robust.

With code samples from a simple speech recognition application, SRSample, this article shows you how to quickly get started using the Speech Recognition Manager. You'll also get some tips on how to make your application's use of speech recognition compelling, intuitive, and reliable. For everything you need in order to use the Speech Recognition Manager in your application (including SRSample and detailed documentation), see this issue's CD or Apple's speech technology Web site at <http://www.speech.apple.com>.

WHAT THE SPEECH RECOGNITION MANAGER CAN AND CANNOT DO

The Speech Recognition Manager consists of an API and a recognition engine. Under System 7.5, these are packaged together in version 1.5 or later of the Speech Recognition extension. (This packaging may change in future OS versions.)

The Speech Recognition Manager runs only on Power Macintosh computers with 16-bit sound input. Speech recognition is simply too computation-intensive to run

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well on most 680x0 systems. The installed base of Power Macs is growing by about five million a year, however, so plenty of machines — including the latest PowerPC™ processor-based PowerBooks — can run speech recognition.

The current version of the Speech Recognition Manager has the following capabilities and limitations:

- It's speaker independent, meaning that users don't need to train it before they can use it.
- It recognizes continuous speech, so users can speak *naturally*, without — pausing — between — words.
- It's designed for North American adult speakers of English. It's not localized yet, and in general it won't work as well for children.
- It supports command-and-control recognition, not dictation. It works well when your application asks it to listen for at most a few dozen phrases at a time; however, it can't recognize arbitrary sentences and its accuracy decreases substantially if the number of utterances it's asked to listen for grows too large. For example, it won't accurately recognize one name out of a list of five thousand names.

OVERVIEW OF THE SPEECH RECOGNITION MANAGER API

To use the Speech Recognition Manager, you must first open a *recognition system*, which loads and initializes the recognition toolbox. You then allocate a *recognizer*, which listens to a *speech source* for sound input. A recognizer might also display a *feedback window* that shows the user when to speak and what the recognizer thinks was said.

To define the spoken utterances that the recognizer should listen for, you build a *language model* and pass it to the recognizer. A language model is a flexible network of words and phrases that defines a large number of possible utterances in a compact and efficient way. The Speech Recognition Manager lets your application rapidly change the *active* language model, so that at different times your application can listen for different things.

After the recognizer is told to start listening, it sends your application a *recognition result* whenever it hears the user speak an utterance contained in the current language model. A recognition result contains the part of the language model that was recognized and is typically sent to your application via Apple events. (Alternatively, you can request notification using callbacks if you cannot support Apple events.) Your application then processes the recognition result to examine what the user said and responds appropriately.

Figure 1 shows how the Speech Recognition Manager works. Note that the telephone speech source is not supported in version 1.5 of the Speech Recognition extension.

SPEECH OBJECTS

The recognition system, recognizer, speech source, language models, and recognition results are all objects belonging to classes derived from the `SRSpeechObject` class, in accordance with object-oriented design principles. These and other objects are arranged into the class hierarchy shown in Figure 2. The class hierarchy gives the Speech Recognition Manager API the flexibility of polymorphism. For example, you can call the routine `SRReleaseObject` to dispose of any `SRSpeechObject`.

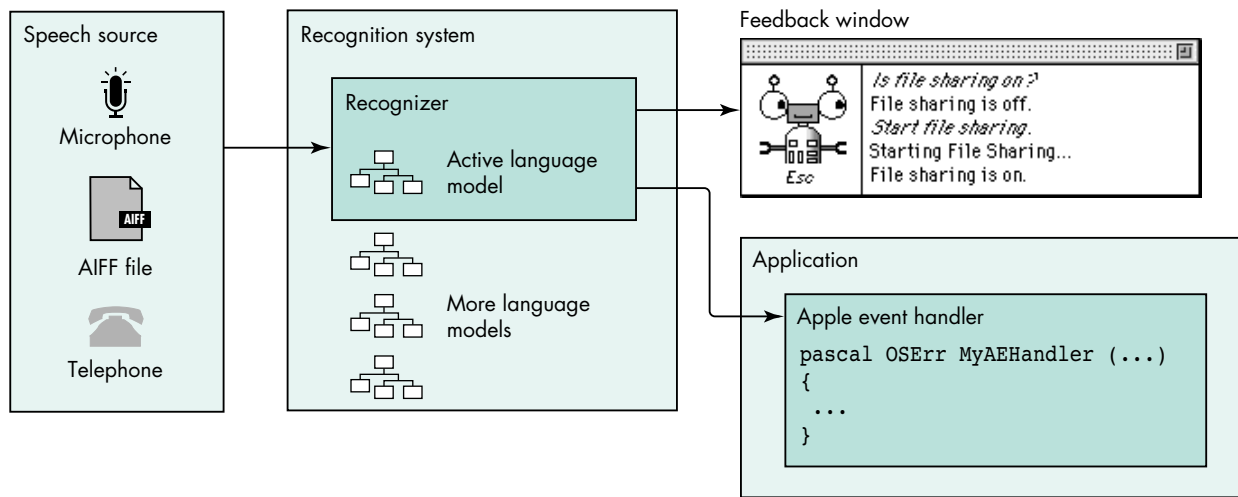


Figure 1. How the Speech Recognition Manager works

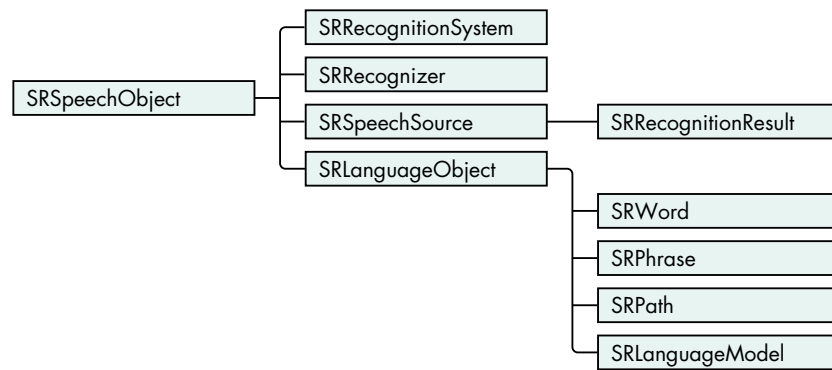


Figure 2. The speech object class hierarchy

The most important speech objects are as follows:

- **SRRecognitionSystem** — An application typically opens one of these at startup (by calling `SROpenRecognitionSystem`) and closes it at shutdown (by calling `SRCloseRecognitionSystem`). Applications allocate other kinds of objects by calling routines like `SRNewWord`, which typically take the `SRRecognitionSystem` object as their first argument.
- **SRRecognizer** — An application gets an `SRRecognizer` from an `SRRecognitionSystem` by calling `SRNewRecognizer`. The `SRRecognizer` does the work of recognizing utterances and sending recognition results back to the application. It begins doing this whenever the application calls `SRStartListening` and stops whenever the application calls `SRStopListening`.
- **SRLanguageModel, SRPath, SRPhrase, SRWord** — An application builds its language models from these object types, which are all subclasses of `SRLanguageObject`. (A *phrase* is a sequence of one or more words, and a *path* is a sequence of words, phrases, and language models.) A language model, in turn, describes what a user can say at any given moment. For example, if an application displayed ten animals and wanted to allow the user to say any of the animals' names, it might build a language model containing ten phrases, each corresponding to an animal's name.

-
- **SRRecognitionResult** — When an utterance is recognized, an **SRRecognitionResult** object is sent (using either an Apple event or a callback routine, whichever the application prefers) to the application that was listening for that utterance. The **SRRecognitionResult** object describes what was recognized. An application can then look at the result in several forms: as text, as **SRWords** and **SRPhrases**, or as an **SRLanguageModel**, which can assist in quickly interpreting the uttered phrase.

Each class of speech object has a number of properties that define how the objects behave. For example, all descendants of **SRLanguageObject** have a **kSRSpelling** property that shows how they're spelled. Your application uses the **SRSetProperty** and **SRGetProperty** routines to set and get the various properties of each these objects.

RELEASING OBJECT REFERENCES

You create objects by calling routines like **SRNewRecognizer** and **SRNewWord**. When you've finished using them, you dispose of them by calling **SRReleaseObject**. You can also acquire references to existing objects by calling routines like **SRGetIndexedItem** (for example, to get the second word in a phrase of several words).

The Speech Recognition Manager maintains a reference count for each object. An object's reference count is incremented by **SRNew...** and **SRGet...** calls, and is decremented by calls to **SRReleaseObject**. An object gets disposed of only when its reference count is decremented to 0. Thus, to avoid memory leaks, your application *must* balance every **SRNew...** or **SRGet...** call with a call to **SRReleaseObject**.

A SIMPLE SPEECH RECOGNITION EXAMPLE

It's easy to add simple speech recognition capabilities to your application. All you need to do is perform a small number of operations in sequence:

1. Initialize speech recognition by determining whether a valid version of the Speech Recognition Manager is installed, opening an **SRRecognitionSystem**, allocating an **SRRecognizer**, and installing an Apple event handler to handle recognition result notifications.
2. Build a language model that specifies the utterances your application is listening for.
3. Set the recognizer's active language model to the one you built and call **SRStartListening** to start listening and processing recognition result notifications.

We'll describe each of these operations in more detail.

INITIALIZING SPEECH RECOGNITION

First, you must verify that a valid version of the Speech Recognition Manager is installed on the target machine. Listing 1 shows how to do this. Note that only versions 1.5 and later of the Speech Recognition Manager adhere to the API used in this article.

Listing 2 shows how to open an **SRRecognitionSystem**, allocate an **SRRecognizer**, and install your Apple event handler. All of this happens when your application starts up. The Apple event handler **HandleRecognitionDoneAE** is shown later (in Listing 4).

Listing 1. Determining the Speech Recognition Manager version

```
Boolean HasValidSpeechRecognitionVersion (void)
{
    OSErr          status;
    long           theVersion;
    Boolean        validVersion          = false;
    const unsigned long kMinimumRequiredSRMVersion = 0x00000150;

    status = Gestalt(gestaltSpeechRecognitionVersion, &theVersion);
    if (!status)
        if (theVersion >= kMinimumRequiredSRMVersion)
            validVersion = true;

    return validVersion;
}
```

Listing 2. Initializing the Speech Recognition Manager

```
/* Our global variables */
SRRecognitionSystem gRecognitionSystem = NULL;
SRRecognizer        gRecognizer        = NULL;
SRLanguageModel     gTopLanguageModel  = NULL;
AEEEventHandlerUPP  gAERoutineDescriptor = NULL;

OSErr InitSpeechRecognition (void)
{
    OSErr status = kBadSRMVersion;

    /* Ensure that the Speech Recognition Manager is available. */
    if (HasValidSpeechRecognitionVersion()) {
        /* Open the default recognition system. */
        status = SROpenRecognitionSystem(&gRecognitionSystem,
                                         kSRDefaultRecognitionSystemID);

        /* Use standard feedback window and listening modes. */
        if (!status) {
            short feedbackNeeded = kSRHasFeedbackHasListenModes;

            status = SRSetProperty(gRecognitionSystem,
                                   kSRFeedbackAndListeningModes, &feedbackNeeded,
                                   sizeof(feedbackNeeded));
        }

        /* Create a new recognizer. */
        if (!status)
            status = SRNewRecognizer(gRecognitionSystem, &gRecognizer,
                                     kSRDefaultSpeechSource);

        /* Install our Apple event handler for recognition results. */
        if (!status) {
            status = memFullErr;
        }
    }
}
```

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Listing 2. Initializing the Speech Recognition Manager (*continued*)

```
gAERoutineDescriptor =
    NewAEEventHandlerProc(HandleRecognitionDoneAE);
if (gAERoutineDescriptor)
    status = AEInstallEventHandler(kAESpeechSuite, kAESpeechDone,
        gAERoutineDescriptor, 0, false);
}
}

return status;
}
```

Notice in Listing 2 how we call `SRSetProperty` to request Apple’s standard feedback and listening modes for the recognizer. To have a successful experience with speech recognition, users need good feedback indicating when the recognizer is ready for them to talk and what utterances the recognizer has recognized (for more on giving feedback, see “Speech Recognition Tips”). In addition, because of the recognizer’s tendency to misinterpret background conversation and noises as speech, it’s usually a good idea to let the user tell the recognizer when to listen by pressing a predefined key (the “push-to-talk” key). Your application can get all of this important behavior for free, simply by setting the `kSRFeedbackAndListeningModes` property.

With Apple’s Speech control panel (which comes bundled on new Macintoshes and with system updates), users can tailor this behavior to suit their needs, choosing preferred feedback characters (that is, the cartoon faces displayed in the feedback window) and preferred push-to-talk keys.

BUILDING A SIMPLE LANGUAGE MODEL

Your application needs to build a language model — `gTopLanguageModel` in our sample code — that specifies what the recognizer is listening for. The routine in Listing 3 shows how your application can create a simple language model. (We’ll discuss fancier language models later in this article.) Even simple language models should avoid using phrases that sound similar to one another; just like a human listener, the recognizer may have a hard time distinguishing between similar-sounding phrases.

A recognizer returns a special speech object, called the *rejection word*, if it hears an utterance but cannot recognize it. Listing 3 sets the reference constant of the top-level language model to a predefined value to be able to distinguish that model from the rejection word.

Note in Listing 3 that we add the phrases “Hello,” “Goodbye,” and “What time is it?” to our `gTopLanguageModel` using the call `SRAddText`, a convenient shortcut for the sequence of calls `SRNewPhrase`, `SRAddLanguageObject`, and `SRReleaseObject`. `SRAddText` also sets the `kSRRefCon` property of each added phrase. We’ll use this reference constant when we examine the recognition result to help determine what was said.

HANDLING RECOGNITION RESULT NOTIFICATIONS

Now let’s look at how your application would process result notifications given this simple language model.

SPEECH RECOGNITION TIPS

Speech recognition is a completely new input mode, and using it properly isn't always as straightforward as it might seem. While we don't yet have a complete set of human interface guidelines to guarantee a consistent and intuitive speech recognition user experience, there are a few simple rules that all speech recognition applications should follow.

GIVE FEEDBACK

Your application must always provide feedback to let users know when they can speak, when their utterance has been recognized, and how it was interpreted. The feedback services in the Speech Recognition Manager perform this for you, using the standard feedback window shown in Figure 3. (The user's recognized utterances are shown in italics, and the displayed feedback is in plain text. The string under the feedback character's face indicates the push-to-talk key.) All you need to do is set the `kSRFeedbackAndListeningModes` property as shown in Listing 2.



Figure 3. Standard feedback window

Your application should use this standard feedback behavior unless you have a very good reason to provide your own feedback and custom push-to-talk options. (Fast action games that take over the entire screen and don't call `WaitNextEvent` are examples of applications that wouldn't use the standard feedback.) Not only will users enjoy the benefits of consistent behavior, but as Apple improves the feedback components, your speech

recognition applications will automatically inherit this improved behavior without having to be recompiled.

SHOW WHAT CAN BE SAID

Successful speech recognition applications always let the user know what he or she can say. The way they achieve this depends on the application, but one good example is a Web browser that makes all visible hyperlinks speakable. This lets the user know what can be said while restricting the size of the language model to improve recognition accuracy.

CONSTRAIN THE LANGUAGE MODEL

The recognition technology currently used by the Speech Recognition Manager works best when it's listening for a small number of distinct utterances. The longer an utterance is, the more easily it can be distinguished from other utterances. For example, distinguishing the isolated words *hot*, *cut*, and *quit* is difficult and error prone. Recognition performance also decreases as the language model grows. The larger the language model, the more time the recognizer must spend searching for a matching utterance and the larger the likelihood of two utterances in the language model sounding similar. For best results, limit the size of the language model to fewer than a hundred phrases at any time and avoid including phrases that are easily confused when spoken, like "wreck a nice beach" and "recognize speech."

DO SOMETHING DIFFERENT

Compelling applications of speech recognition are often novel ones. Instead of simply paralleling an application's graphical user interface with a spoken one (making all menu items speakable, for example), do something different — something that takes advantage of the unique properties of speech. Combine speech synthesis with speech recognition to engage the user in a brief dialog. Use efficient language models to allow a single utterance to trigger a series of commands that might otherwise require interaction with dialog boxes. Let the power of speech recognition augment the graphical interface your users are already familiar with. Use your imagination!

In Listing 4, `HandleRecognitionDoneAE`, our Apple event handler, uses the routine `AEGetParamPtr` to extract the status of the result as well as the recognizer and recognition result objects from the Apple event.

At this point, the Apple event handler could easily get the text of what was heard by getting the `kSRTEXTFormat` property of the recognition result. But a more useful form of the result is the `kSRLanguageModelFormat`. This language model parallels the language model `gTopLanguageModel`, but instead of containing all of the phrases "Hello," "Goodbye," and "What time is it?" it contains only a copy of the phrase

Listing 3. Building a simple language model

```
OSErr BuildLanguageModel (void)
{
    OSErr      status;
    const char  kLMName[]  = "<Top LM>";

    /* First, allocate the gTopLanguageModel language model. */
    status = SRNewLanguageModel(gRecognitionSystem, &gTopLanguageModel, kLMName, strlen(kLMName));
    if (!status) {
        long refcon = kTopLMRefcon;

        /* Set the reference constant of our top language model so that when we process our */
        /* recognition result, we'll be able to distinguish it from the rejection word, "???". */
        status = SRSetProperty(gTopLanguageModel, kSRRefCon, &refcon, sizeof(refcon));
        if (!status) {
            const char *kSimpleStr[] = { "Hello", "Goodbye", "What time is it?", NULL };
            char **currentStr = (char **) kSimpleStr;
            long refcon = kHelloRefCon;

            /* Add each of the strings in kSimpleStr to the language model, and set the refcon to */
            /* the index of the string in the kSimpleStr array. */
            while (*currentStr && !status) {
                status = SRAddText(gTopLanguageModel, *currentStr, strlen(*currentStr), refcon++);
                ++currentStr;
            }

            /* Augment this simple language model with a fancier one. */
            if (!status)
                status = AddFancierLanguageModel(gTopLanguageModel);
        }
    }
    return status;
}
```

Listing 4. Handling the recognition-done Apple event

```
pascal OSErr HandleRecognitionDoneAE (AppleEvent *theAEvt, AppleEvent *reply, long refcon)
{
    OSErr      recognitionStatus = 0, status;
    long       actualSize;
    DescType   actualType;

    /* Get recognition result status. */
    status = AEGetParamPtr(theAEvt, keySRSpeechStatus, typeShortInteger, &actualType,
        (Ptr) &recognitionStatus, sizeof(recognitionStatus), &actualSize);

    /* Get the SRRecognizer. */
    if (!status && !recognitionStatus) {
        SRRecognizer recognizer;
        status = AEGetParamPtr(theAEvt, keySRRecognizer, typeSRRecognizer, &actualType,
            (Ptr) &recognizer, sizeof(recognizer), &actualSize);
    }
}
```

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Listing 4. Handling the recognition-done Apple event (*continued*)

```
/* Get the SRRecognitionResult. */
if (!status) {
    SRRecognitionResult recResult;
    status = AEGetParamPtr(theAEvt, keySRSpeechResult, typeSRSpeechResult, &actualType,
        (Ptr) &recResult, sizeof(recResult), &actualSize);

    /* Extract the language model from the result. */
    if (!status) {
        SRLanguageModel resultLM;
        long propertySize = sizeof(resultLM);

        status = SRGetProperty(recResult, kSRLanguageModelFormat, &resultLM, &propertySize);

        /* Process the language model. */
        if (!status) {
            status = ProcessRecognitionResult(resultLM, recognizer);

            /* What we SRGot we must SRRelease! */
            SRReleaseObject(resultLM);
        }
        /* Also release the recognition result. */
        SRReleaseObject(recResult);
    }
}
return noErr;
}
```

that was recognized. For example, if the user said “Goodbye,” the language model returned in the `kSRLanguageModelFormat` property would contain one phrase, which would have a `kSRSpelling` property of “Goodbye” and a `kSRRefCon` property of 1 (the value passed for that phrase in the `SRAddText` call in Listing 3). The `ProcessRecognitionResult` routine (Listing 5) uses the language model to determine what was said by getting the `kSRRefCon` property of the spoken phrase and responding appropriately.

This example uses the `SRSpeakAndDrawText` routine to respond to recognition events. The Speech Recognition Manager uses the Speech Synthesis Manager to speak the string, and the animated feedback character (displayed in Apple’s standard feedback window) lip-synchs with the synthesized text. The Speech Recognition Manager also displays the response text in the feedback window. (You can use other routines to simply speak a string through the feedback window without displaying it, or to display a string without speaking it.)

SETTING THE ACTIVE LANGUAGE MODEL AND STARTING TO LISTEN

All we need to do now is make the language model we’ve built, `gTopLanguageModel`, the *active* language model and tell our recognizer to start listening. First we call the `SRSetLanguageModel` function, which associates `gTopLanguageModel` with the `SRRecognizer` we’ve allocated, `gRecognizer`:

```
OSErr status = SRSetLanguageModel(gRecognizer, gTopLanguageModel);
```

Listing 5. Processing a recognition result

```
OSErr ProcessRecognitionResult (SRLanguageModel resultLM, SRRecognizer recognizer)
{
    OSErr    status = noErr;

    if (resultLM && recognizer) {
        long    refcon;
        long    propertySize = sizeof(refcon);

        /* Get the refcon of the root object */
        status = SRGetProperty(resultLM, kSRRefCon, &refcon, &propertySize);

        /* Is the resultLM a subset of our top language model or is it the rejection word, "???"? */
        if (!status && refcon == kTopLMRefcon) {
            SRLanguageObject languageObject;
            propertySize = sizeof(languageObject);

            /* The resultLM contains either an SRPhrase or an SRPath. We use the refcon property */
            /* set in our language model building routine to distinguish between the results. */

            /* Get the phrase or path. */
            status = SRGetIndexedItem(resultLM, &languageObject, 0);
            if (!status) {
                long refcon;
                propertySize = sizeof(refcon);

                /* Get the refcon of the language object. */
                status = SRGetProperty(languageObject, kSRRefCon, &refcon, &propertySize);
                if (!status) switch (refcon) {
                    case kHelloRefCon:
                    case kGoodbyeRefCon:
                    case kWhatTimeIsItRefCon:
                        {
                            const char *kResponses[] = { "Hi there!", "Don't leave now!",
                                                            "It's time to use the Speech Recognition Manager!"
                                                        };

                            /* Speak and display our response using the feedback character. */
                            /* Use the refcon as an index into our response array. */
                            status = SRSpeakAndDrawText(recognizer, kResponses[refcon],
                                                            strlen(kResponses[refcon]));
                        }
                        break;
                    case kCompanyRefCon:
                        status = ProcessFancierLanguageModel(languageObject, recognizer);
                        break;
                }
                /* Always SRRelease what we SRGot. */
                status = SRReleaseObject(languageObject);
            }
        }
    }
    return status;
}
```

You can build as many language models as you like, but there is always just one that's active. You can make another language model active (and thereby deactivate the one that was previously active), or you can enable and disable parts of the active language model. Typically this is done in response to a speech-detected Apple event, sent to the application when recognition is about to begin.

For a good example of making your language model dynamically conform to the context of your application, see the article "Adding Speech Recognition to an Application Framework" in this issue of *develop*. •

Once we've set the active language model, we start the recognition process by calling `SRStartListening`, as follows:

```
if (!status)
    status = SRStartListening(gRecognizer);
```

Now we can start speaking to our application. When an utterance is recognized as belonging to our language model, our Apple event handler, `HandleRecognitionDoneAE`, will be called and the recognition result will be processed. It's that easy!

CLEANING UP

Listing 6 shows how to clean up when your application quits. In general, you should release the speech objects in the order shown.

BUILDING FANCIER LANGUAGE MODELS

The Speech Recognition Manager provides several routines that your application can use to create and manipulate fancier language models than the one created earlier in Listing 3. For example, suppose you wanted to create an application that responds to users when they say, "Tell me the price of <company> stock," where <company> is one of several company names.

To create a language model like this, your application needs to create an `SRPath` object that consists of the phrase "Tell me the price of" followed by an *embedded* language model representing the company names, followed by the word "stock." The `AddFancierLanguageModel` function creates this path and adds it to the language model created in Listing 3. (Note that the embedded company language model is simply a list of phrases, just like the language model we created in Listing 3.)

Figure 4 shows the structure of the entire language model. We've limited the number of companies to three here for simplicity. The top half of each box shows the spelling and refcon properties of each object; the lower half indicates the object type.

Take a look at the `AddFancierLanguageModel` function (not shown, but included with our sample code) to see how to build the fancier language model. (Don't worry if this routine seems like a lot of code just to add the command "Tell me the price of <company> stock"; below we'll describe the `SRLanguageModeler` tool, which makes the creation of complicated static language models very easy.) Listing 7 shows how your application would process results given this fancier language model.

Speech recognition applications that support utterances like "Tell me the price of <company> stock" or "Call <name>," while limiting <company> or <name> to a few dozen items, can be more compelling than those that just respond to simple phrases. They're nicely limited in scope, yet they allow the user to invoke actions more easily than would be possible with a graphical user interface. What other technology does that?

Listing 6. Terminating speech recognition

```
void TerminateSpeechRecognition (void)
{
    OSErr status = noErr;

    /* If we have an active language model, release it. */
    if (gTopLanguageModel) {
        status = SRReleaseObject(gTopLanguageModel);
        gTopLanguageModel = NULL;
    }

    /* If we have a recognizer, release it. */
    if (gRecognizer) {
        status = SRStopListening(gRecognizer);
        status = SRReleaseObject(gRecognizer);
        gRecognizer = NULL;
    }

    /* If we have a recognition system, close it. */
    if (gRecognitionSystem) {
        status = SRCloseRecognitionSystem(gRecognitionSystem);
        gRecognitionSystem = NULL;
    }

    /* Remove our Apple event handler and dispose of the handler's */
    /* routine descriptor. */
    if (gAERoutineDescriptor) {
        status = AERemoveEventHandler(kAESpeechSuite, kAESpeechDone,
                                      gAERoutineDescriptor, false);
        DisposeRoutineDescriptor(gAERoutineDescriptor);
        gAERoutineDescriptor = NULL;
    }
}
```

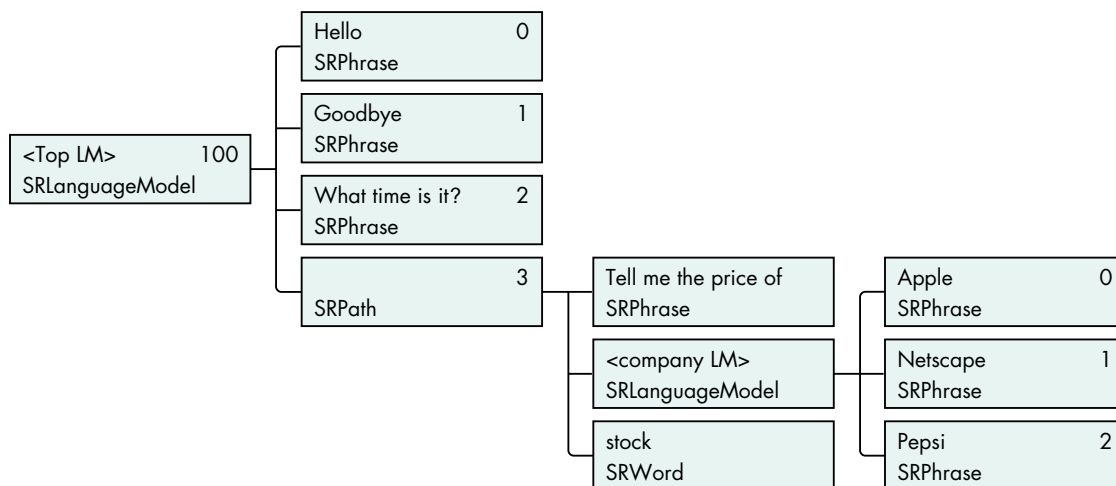


Figure 4. Language model built by calling BuildLanguageModel

Listing 7. Processing a recognition result given a fancier language model

```
OSErr ProcessFancierLanguageModel (SRPath resultPath, SRRecognizer recognizer)
{
    OSERR    status = noErr;

    if (resultPath && recognizer) {
        SRLanguageModel companyLM;

        /* Get the second item in the path -- it's the company language model. */
        status = SRGetIndexedItem(resultPath, &companyLM, 1);
        if (!status && companyLM) {
            SRPhrase companyName;

            /* In the result language model, the company language model contains just one phrase. */
            status = SRGetIndexedItem(companyLM, &companyName, 0);
            if (!status) {
                long refcon;
                long propertySize = sizeof(refcon);

                /* Get the refcon from the company name. It's our index into the response array. */
                status = SRGetProperty(companyName, kSRRefCon, &refcon, &propertySize);
                if (!status) {
                    const char *kResponses[] =
                        { "Apple stock is priced to move!",
                          "Netscape is trading at fifty dollars.",
                          "Why would you want to know that?"
                        };
                    status = SRSpeakAndDrawText(recognizer, kResponses[refcon],
                                                strlen(kResponses[refcon]));
                }
                /* What we SRGot we must SRRelease. */
                status = SRReleaseObject(companyName);
            }
            status = SRReleaseObject(companyLM);
        }
    }
    return status;
}
```

MANIPULATING LANGUAGE MODELS

The Speech Recognition Manager contains several more routines and properties for manipulating language models. We'll look at a few of them here.

Your application can create a large language model and then use the `SRSetsProperty` function to disable and enable parts of it quickly on the fly, as shown in Listing 8. By enabling only parts of a language model, you can minimize the number of utterances that the recognizer is listening for.

Your application can change, clear, or rebuild parts of a language model dynamically to reflect the current context of your program. Listing 9 clears and then rebuilds the company language model that was originally built by the `AddFancierLanguageModel` function.

Listing 8. Disabling a part of a language model

```
/* Disable the stockPath part of the gTopLanguageModel. */
/* The stock path is the fourth item in this language model. */

SRPath    stockPath;
OSErr     status = SRGetIndexedItem(gTopLanguageModel, &stockPath, 3);

if (!status) {
    Boolean enabled = false;
    status = SRSetProperty(stockPath, kSREnabled, &enabled,
                           sizeof(enabled));

    /* Balance SRGet call. */
    status = SRReleaseObject(stockPath);
}
```

Listing 9. Emptying and refilling the company language model

```
/* Empty and refill the embedded company language model. */
/* Assume that stockPath has already been initialized. */

/* The companyLM is the second item in the stock path. */
SRLanguageModel    companyLM;
OSErr               status = SRGetIndexedItem(stockPath, &companyLM, 1);

if (!status) {
    /* This releases each phrase in the company language model. */
    status = SREmptyLanguageObject(companyLM);

    /* Now rebuild the company language model with new companies. */
    if (!status) {
        const char    *kNewCompanies[] = { "I B M", "Motorola",
                                             "Coca-Cola", NULL };

        char          **company        = (char **) kNewCompanies;
        long           refcon          = 0;

        while (*company && !status) {
            status = SRAddText(companyLM, *company, strlen(*company),
                               refcon++);

            ++company;
        }
    }
    SRReleaseObject(companyLM);
}
```

At any given moment, the active language model should be relatively small, but your application can change the set of active phrases at any time. For example, if a Web browser application made its links speakable, at any given moment there would only be a few dozen visible links, so there would only be a few dozen phrases active. But if you spent a couple of hours surfing the Web with that browser, you would have seen many thousands of links throughout the session, and you could have spoken any one of them while it was visible.

In addition to enabling and disabling parts of your language model, the `SRSetProperty` function allows your application to make words, phrases, paths, or language models repeatable (so that the user can say that item one or more times in a row) or rejectable (so that if the user says something else for that item, the recognizer will fill it in with a special rejection word with a spelling of “???”).

Your application can also make any word, phrase, path, or language model optional by setting the corresponding object’s `kSROptional` property to true. In `AddFancierLanguageModel`, we’ve set the `kSROptional` property of the `SRWord` “stock” to true, so the recognizer is ready for the user to say, “Tell me the price of Apple” as well as “Tell me the price of Apple stock.”

Your application doesn’t have to build language models from scratch each time it runs. The Speech Recognition Manager provides routines for saving and loading language objects (for example, the `SRPutLanguageObjectIntoHandle` and `SRNewLanguageObjectFromFile` routines). Listing 10 shows an example.

Listing 10. Saving a language model into a resource

```
/* Allocate a handle of size 0 to store our language model in; */
/* SRPutLanguageObjectIntoHandle will resize it as needed. */
Handle  lmHandle = NewHandle(0);
OSErr   status   = MemError();

if (!status) {
    status = SRPutLanguageObjectIntoHandle(gTopLanguageModel, lmHandle);
    if (!status) {
        /* Save the language model as a resource in the current */
        /* resource file. Pick a reasonable resource type and ID. */
        AddResource(lmHandle, 'LMDL', 100, "\pTop Language Model");

        /* Make sure it gets written to disk. */
        if (!(status = ResError())) {
            WriteResource(lmHandle);
            DetachResource(lmHandle);
        }
    }

    DisposeHandle(lmHandle);
}
```

Apple provides a very handy developer tool, called `SRLanguageModeler`, that you can use to quickly create, test, and save language models into resources or data files. You can find this tool, and documentation for it, with the other Speech Recognition Manager developer information on this issue’s CD and on the speech technology Web site. `SRLanguageModeler` lets you write out a language model in a relatively simple text form and then try it out to see how well its phrases can be recognized and discriminated from one another. It lets you save the language models into a binary resource or file format that you can ship with your application. Your application can load the language model at run time with `SRNewLanguageObjectFromHandle` or `SRNewLanguageObjectFromFile`. `SRLanguageModeler` will eliminate a lot of the code you would otherwise have to write to construct the static parts of your language models.

SPEECH: THE FINAL FRONTIER

If you've understood this article, you'll have no problem making practical use of speech recognition in your application. From the basics of checking for the proper version of the Speech Recognition Manager to some of the finer details of building language models, we've shown you everything you need to know to get started. Be sure to take a look at the SRSample application, which uses many of the listings in this article.

To dig even deeper, check out the Speech Recognition Manager documentation and the SRLanguageModeler tool. For tips on using the Speech Recognition Manager within an application framework and dynamically changing your language model, see the article "Adding Speech Recognition to an Application Framework" in this issue of *develop*. Then have fun turning your application into a good listener.

RELATED READING

- "Speech Recognition Manager," on this issue's CD and on Apple's speech technology Web site, <http://www.speech.apple.com>.
- "Adding Speech Recognition to an Application Framework" by Tim Monroe, in this issue of *develop*.

Thanks to our technical reviewers Mike Dilts, Eric "Braz" Ford, Tim Monroe, and Guillermo Ortiz. •



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