Using a Barrel of Monkeys in Computer Science*

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Abstract

Experiences in using the common *Barrel of Monkeys*® toy to teach concepts related to dynamically allocated linked lists are presented.

Motivation

The use of tangible models in the classroom (at all levels of instruction) is incredibly common. Computer science instruction is certainly no exception; the computer science education literature is filled with examples of toys and models used to demonstrate various key concepts (see for example [2, 3]).

I frequently teach our university's CS2 course, which has as one of its foci the concept of dynamically allocated linked lists. In the classroom, I have used traditional means to present and reinforce the topic: comparison with array-based lists, traditional "box-and-arrow" pointer diagrams (used in many textbooks, *e.g* [5]), and of course implementation code.

Several years ago, I started referring to the classic *Barrel of Monkeys*® toy as I presented the concept of linked lists. I tried to evoke students' memories of the toy as we discussed various concepts. (I suspect that more of my students remember the toy from its cameo appearance in *Toy Story* than ever played with it themselves.) I had varying degrees of success as I held up imaginary chains of monkeys and waved my hands in the air. Eventually, it occurred to me that the actual toy probably still existed. To my surprise I discovered one at my local toy store (with the help of a store clerk who was happy to re-live her own experiences with the toy). I've used it in the classroom ever since.

Using the Toy

For those not familiar with the toy, the standard *Barrel of Monkeys*® consists of a large number of individual monkey pieces, each about 7cm by 5cm in size. Each monkey has its arms extended in a hook shape in opposite directions. These arms can easily be interlinked to form a chain of monkeys, which is the intended use of the toy. (Imprinted on the barrel are instructions for a couple of simple games.)

The toy can be used straight out of the package (as I did for the first few years). I typically put together a chain of five or six monkeys and hang them from a finger on one hand, holding the chain up high enough for students to see. This immediately illustrates one key point: the pointer/reference (hereafter "pointer") to the first item in the list gives one access to the entire data structure. Lifting and lowering that pointer finger[1], and thus the entire chain, illustrates that fact dramatically.

This also establishes a dramatic visual difference between objects (the monkeys) and pointers (the human fingers or monkey arms that attach to monkeys). In particular, using a finger as a representation of a pointer is very natural, since fingers are a natural pointing device (perhaps the original one).

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[1]Caution: be careful about which figure you use as the pointer finger. One's middle finger is awfully tempting due to its length and strength, but may lead to an awkward moment as you display that finger to the class . . .

One point of awkwardness that became apparent after a couple of uses comes from the uniform appearance of the monkeys. Each monkey is made from the same red plastic; while this re-affirms that each node is just like any other node, it becomes awkward when discussing algorithms involving multiple different nodes. ("To insert a monkey at *this* point in the list, you have to change *this* pointer to point *here*, and then *this other* pointer to point *here*.")

I happened to have some old cans of spray paint at the time, so I took the monkeys home and painted them. This gave me a collection of four or five contrasting colors of monkeys. This made those discussions much easier. ("To insert a blue monkey between the white and red monkeys, you make the blue monkey point to the red monkey, and then you make the white monkey point to the blue monkey.")

Regarding spray paints: it's been my experience that these spray paints tend to disintegrate over time and especially with repeated use. Some spray paints seem to adhere better than others; you may have to experiment to find a set that works for you. (The paints I'm using seem to last about three years between applications.)

Also, be careful in your selection of colors. Obviously, for this sort of public display, and given the relatively small size of the monkeys, bold, contrasting colors are preferred. I also avoid using brown or black as colors, given the unfortunate perjorative use of the term "monkey" to refer to people of African descent.

You will undoubtedly discover over time that while working with chains of monkeys, especially in front of a group of students, it is extremely easy to drop monkeys on the floor. This is actually beneficial. It reinforces the fact that pointer manipulation creates the potential for losing access to allocated nodes (after all, there are no fingers pointing to the monkeys on the floor). The monkeys lying on the floor are easily described as "garbage", whose eventual disposition may be handled by a "garbage collector" (or, alternatively, lead to no more monkeys being available). And, of course, students always enjoy laughing at (with?) their instructors when things go wrong. I find that I've actually gotten a little *too* good at manipulating chains of monkeys and have to rather deliberately drop a monkey or two on the floor at key moments.

I teach in relatively small classrooms (usually no more than 30 students); usually, students can see the display without much difficulty. If your classrooms are much larger, you may want to consider using some sort of simple projection equipment (a webcam attached to a projected computer may be sufficient).

Technically, a chain of monkeys really models a doubly-linked list more closely than a singly-linked list, since each monkey has two arms. This distinction can be easily ignored at first (none of my students have ever noticed this right off), and perhaps highlighted later as time permits.

Any number of other possible enhancements could be made, depending on your emphasis. The "barrel" could be viewed as a model for a memory heap, holding a collection of different yet equivalent nodes for available use. The "bodies" of the monkeys could be enhanced to store actual data (perhaps by attaching items of interest to the monkey bodies). Other ideas undoubtedly exist.

Acknowledgements

References

[1] Christine Ammer, *American Heritage Dictionary of Idioms*, Houghton Mifflin, 1997. (Available online at `http://dictionary.reference.com`)

[2] Owen Astrachan, "Concrete teaching: hooks and props as instructional technology", Proceedings of the 6th annual conference on the teaching of computing and the 3rd annual conference on Integrating technology into computer science education, Dublin City Univ., Ireland, 1998, 21–24.

[3] Tim Bell, Ian H. Witten, and Mike Fellows, *Computer Science Unplugged*. Available as shareware from `http://unplugged.canterbury.ac.nz`

[4] *Milton Bradley Company History*, `http://www.hasbro.com/pl/page.corporate_history_mb/`

[5] Thomas A. Standish, *Data Structures in Java*. Addison-Wesley, 1998.