This is one of a series of articles on directed word chain networks. The concept of a directed word chain network, together with definitions of various terms used to characterize such networks, was introduced in Part 1 of this series. The concept of a word chain dates back at least to Dudeney's 1925 book, The World's Best Word Puzzles (largely reprinted as 300 Best Word Puzzles by Dover in 1968).

This article is limited to regular (8,4) word chain networks. The eight-letter words used here come from Web 2, Web 3, OSPD, and Chambers Words, a list made from the Chambers Twentieth Century Dictionary. Most words can be found in Web 3. My database was extracted from a computerized OSPD list, then expanded by hand search of all the dictionaries including OSPD. The OSPD list (1978) derives from Web 3 (1961), but includes a significant number of relatively new words (a 1991 edition is available). 12000 Words, a supplement to Web 3, contributed a few new words, although most words found there are in OSPD. With respect to Web 3, I accepted words marked "often capitalized" but not "usually capitalized". Scottish and dialect words were accepted.

Eight-letter words were split whether the four-letter frags were words or not. A previous Word Ways article ("Ana-Gram-Mar Chains" November 1990) required that frags be common words, and classified them according to meanings relative to the eight-letter word. I did not do anything like that, but in fact all types of frags did show up.

Appendix A is a selection (read from left to right) of word chains obtained from a database of 2813 eight-letter words with 960 different frags. This is an abstract from the main network, far too complicated to diagram in full. All the chains are interconnected (though many cross-paths are not shown), and some sequences repeated. The four longest irreducible chains (RATS to PATE, VIOL to PATE, VIOL to BLES, and STEE to TOlD) all take 17 steps. This is the one-way span of the network.

What is the two-way span? To aid in the search, some words in the diagram are written in caps; these cannot contribute to a loop in the core. For the others, CONE to BITS takes 10 steps, and BITS to CONE 13, for a round trip of 23; this is the two-way span. Some near-misses are PISH to CONE 14, CONE to PISH 8; MOTH to CONE 11, CONE to MOTH 10; BLES to CONE 12, CONE to BLES 10; and RATS to CONE 16, CONE to RATS 5. MOTH to GENT in 8, and GENT to MOTH in 10, is an interesting pair. Shifting this cycle

DIRECTED WORD CHAIN NETWORKS (PART 2)

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gets two irreducible chains of equal length (note how WOOD is used in both directions):

rice-bird-lime-wood-cock-crow-foot-sore-hawk-moth
moth-worm-wood-side-show-ance-rata-plan-gent-rice

The BLES-CONE loop also appears in Appendix A as an ENCE-CONE loop; this is also a shift in the cycle. A further shift produces two equal chains, but this is not valid, as CONE to BUCK can be reduced:

cone-head-land-wire-bars-poon-tang-ence-inte-grum-bles-buck
buck-wash-down-turn-over-free-zing-anas-arca-dias-pine-cone

Here are a few sequences that do not appear in Appendix A. Most are in the main network, but one or two are isolated. I came across the latter in my search; more undoubtedly exist.

surf-aces-cent-ring
down-cast-rate-able
bast-aard-wolf-rams
tire-dest-roys-ting
nama-quan-dang-ling
drop-kick-shaw-fowl
stam-pede-stal-wart
tops-oils-kins-folk
aspi-rata-plan-cher
yest-reen-list-able
blue-gume-hoed-owns
cali-phal-ange-ring
fool-scrap-hold-ened
flat-beds-traw-lers

surf-aces-cent-ring
down-cast-rate-able
bast-aard-wolf-rams
tire-dest-roys-ting
nama-quan-dang-ling
drop-kick-shaw-fowl
stam-pede-stal-wart
tops-oils-kins-folk
aspi-rata-plan-cher
yest-reen-list-able
blue-gume-hoed-owns
cali-phal-ange-ring
fool-scrap-hold-ened
flat-beds-traw-lers

Of the 960 frags in my database, 119 can only begin, and 142 can only end a chain. 699 may do either. If we eliminate the terminal frags, then some of the others can no longer fill a dual role. Eliminating these and repeating the process four or five times winnows the 699 down to 507. These ideal 507 frags are the core of the network; any one can be reached from any other with an (8,4) word chain. The above two-way span is part of this core. Appendix B gives all 960 frags. Capital letters start the beginners and terminate the enders; those with the middle letters capitalized are the 192 dropouts (preceders and followers).

Using the full 960 list, a fan starting from any of the 507 core frags can reach (sweep) 660 others.

Although my objective when searching the dictionaries was to find eight-letter words that either contributed to the network span or were useful in forming rectangular arrays (discussed in a later article), I included some that seemed to have potential. Several didn't, and merely became appendages to the main network. These are not swept by fans originating within the core, but can become sources for fans. A fan starting with BARA sweeps 675; one start-
ing with THOU, 671; one starting with SOUP, 669; and one starting with ARRE, 667. Here are some details; others can be found in Appendix A.

Most of the 507 core frags can be arranged in a single chain, but that job is not well suited for computer search, and is not for me in any case. On the other hand, the following are suited for computer search. The first is the longest chain in which all frags are in alphabetical order. The second chain uses 23 different starting letters for the frags:

ball-cock-crow-foot-hold-over-seer-ship-side-slip-slop-work

Here are three palindromic chains. Appendix B gives a list of reversible words. A WORKHEAD (Web 3) is part of a lathe or other machine tool.

hang-over-turn-down-take
long-head-work-book-land-folk
come-down-take-over-burn-side-hill

The following looped chains have related four- or eight-letter end words. Both halves of each loop are of the same length. They are usually as short as I could find, although the length of one of the halves was often adjusted to that of the other. Note that a frag sometimes shows in both halves of a loop.

WORK-week-long-hand-PLAY-time-card-case-WORK

The following looped chains have related four- or eight-letter end words. Both halves of each loop are of the same length. They are usually as short as I could find, although the length of one of the halves was often adjusted to that of the other. Note that a frag sometimes shows in both halves of a loop.
Here are chains for which reverse paths are not possible with my list:

- SILK-wood-side-long-WOOL
- JAIL-bird-like-walk-over-FREE
- SOUP-cons-true-blue-stem-head-lock-NUTS
- SHAM-rock-fall-back-REAL

The following table applies to the 507 core frags. The integers give the number of times each frequently-found four-letter frag (by happenchance, all common words as well) appears in the head or tail of an ideal word (one consisting of two core frags). Combinations marked "x" (43 of a possible 145) are actually in the list. LESS is a frequent right frag, but it is not ideal; LESSNESS is the only word beginning with LESS that I have, and NESS goes nowhere. ABLE, LING and TING are bottleneck words; I have only one ideal eight-letter word beginning with each. Also, I have only one eight-letter word ending in FOOT. LIKE is a lesser bottleneck; there are six words, four of them ideal, beginning with LIKE. I included 88 words beginning with FORE in my list so that it might serve as a starter for rectangular arrays (see later article). The only sequence leading to FORE is CANA-PINA-FORE. Although not particularly important for making chains, the variety of WEEDs is interesting; a list is included in Appendix B.

**APPENDIX A**
APPENDIX B

backfall backfire backkick barabara birdcage birdsong boilover bonelfish
backfire bookcase bookland bookwork bootjack burnover burnside cagebird casebook
chowchow coattail comedown couscous deerkill dishwash dividivi dovering
downfall downface downplay downtake downturn facedown fallback fireback
fishbone fishpond folkland ganggang gandpaw greegree handwork hangover
hardpans headlong headwork hillside holdover hookweed hotshouts jackboot
kavakava kickback killdeer kouskous landbook landsfolk lavalava likewise
longhead mateship overboil overburn overhang overhold overlapse overslip
overtake overturn overwing panshard passover piri piri playdown playwag
pondfish ringdove rootworm shipmate shipwork shopwork sideburn sidehill
slipover songbird sailcoat takedown takeover ticktick turndown turnover
washfish weedhook wingover wiselike woodworm workbook workhand workhead
workshop workshop wormroot wormwood
bankweed beanweed bindweed birdweed cockweed
clockweed crowweed deerweed
goldweed hairweed hardweed hawkweed
knottweed lakeweed markweed mintweed
richweed roadweed rockweed sandweed silkweed
silverweed snapweed soapweed
tackweed tickweed towweed wireweed

boleweed bullweed caseweed clayweed
doorweed downweed duckweed heliweed
hookweed ironweed itchweed
pinkweed pokeweed pondweed
silkweed snapweed soapweed
twillweed woolweed wormwood