%3!<%Q%9$+$i$N3J%U%l!<%`H><+F03MF@$
!!!!!!!!!!!!!!;Y1g4D6-$N9=C[

CfDM9,5#　　1'DEO$Ip?N　　>>K\M5<#

F'NI@hC<2J3X5;=QBg3X1!Bg3X!!>pJs2J3X8&5f2J

K\8&5f$NGX7J

!| =>Mh$N?M<j$Khk8@8l=hM}%7%9%F%`$N8@8l<-=q$r9
$k>l9g$NLdBjE@!#

1. KDBg$J8@8lCN<1NL$KH<$&:n6H%3%9%H
2. <-=q$N0l4S@-$NJ];}$N:$Fq@-
3. <-=q$N3HD%$N:$Fq@-
4. FCDjNJ,LnN<-=q9=C[$N:$Fq@-

⇓

8@8l<-=q$NBg5,LO%3!<%Q%9$+iN<+F03MF@$NI,MW@-$
5l$k!#

3J%U%l!<%`3MF@$N4{B8$N4XO'8&5f

- L$2r@O$N%3!<%Q%9$r;HMQ
  —→ [Brent93, Manning93, Briscoe97]
- #18D$N3JMWAG$NHF2=%l%Y%k3X=,!#
  —→ [Resnik93, Li95, Abe96]
- J#?t$N3JMWAG$NHF2=%l%Y%k$N3X=, —→ [=ULn 95]

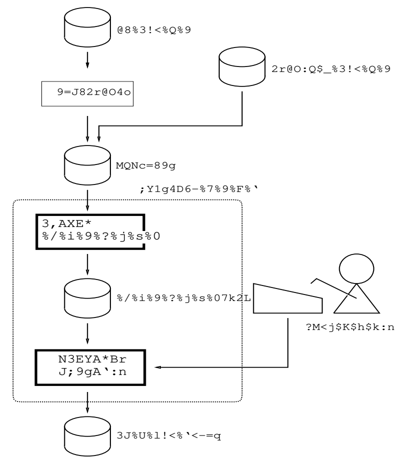
⇓

F0;l$N8l5A$NN`JL$K@dBPE*4p=`$,B8:_$7$J$$!#
I,?\3JHG0U3J$NJ,N`$,MF0WGO$J$$!#

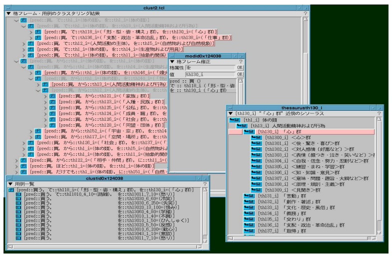
⇓

40A4$J<+F03MF@$O<B8==PMh$F$$$J$$!#

;Y1g4D6-$N%7%9%F%`9=@.?^



#G#U#I$N354Q



#G#U#I$K<BAu$5l?5!G=

!| %$%s%?!<%U%'%9$K$O!"<!$K5s2k5!G=$,$"$k!#

1. 3J%U%l!<%`$NI=<(!"1\Mw5!G= ...
   2<0L$N3J%U%l!<%`$NE83+I=<(, MQNc$N0lMwI=<(
2. 3J%U%l!<%`$N=$@5!"A`:n5!G= ...
   3J%U%l!<%`$NJ;9g, 3J%U%l!<%`$N0\F0
   %/%i%9%?9=B$$NJ?3j2=, 3J%U%l!<%`$N3JMWAG$N=$@5
3. $=$NB>$N5!G= ...
   %7%=!<%i%9$N3,AX9=B$$NI=<(!"F~=PNO%U!%$%k$NA*E

K\8&5f$N35N,

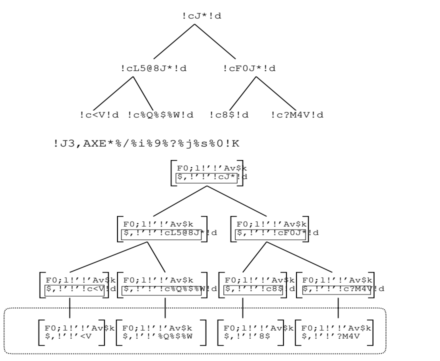
1. 3J%U%l!<%`H><+F03MF@$N;Y1g4D6-$N9=C[
2. 7W;;5!$NH=CG$,IT40A4$JItJ,$r?M<j$K
   hj=$@5$9$k
3. F0;l$NB?5A@-N`JL$rCf?4H7$?H><+F03MF@
   - L>;l$NHF2=%l%Y%k$N8uJd$HI,?\!&G$0U3J$
     JL$O;Y1g4D6-$rbH$K<+F0E*$K3MF@!#
   - F0;l$NB?5A@-N`JL$O!"$"$i$+$8$aM?$(i
     $$$k8l5A$N4p=`$rMQ$$$k!#

MQNc$N%/%i%9%?%j%s%0<jK!

!| #18D$NFCDj$N<43J$KCmL\$7$F!"L>;l$N%7%=!<%i%9$
9=B$$K4p$E$$$F!"MQNc$rJ,3d$9$k!#
!| A4FN2DG=$J3J$r<43JH7$?%/%i%9%?%j%s%0$r!"7
Kh$j=PNO$9$k!#

⇓

Nc!'F0;l!VAv$k!W$NMQNc$r!V$,!W3J$r<43J$KJ,3d!#
!J%7%=!<%i%9!K



3J%U%l!<%`3MF@$N<B837k2L

F0;l	MQNc?t	8l5A?t	<43J	E83+?t	N3EYA*Br8e %/%i%9%??t	J;9gA`:n8e %/%i%9%??t
>e$,$k	303	13	$,	23	72	9
	—	–	$K	14	40	2
D%$k	109	12	$r	15	47	9
	—	–	$,	3	7	1
0z$/	167	18	$r	18	56	14
	—	–	$,	4	11	1
	—	–	$K	5	17	1
?(lk	119	6	$K	16	54	5
$+$+$k	714	19	$,	28	86	15
	—	–	$K	4	19	1
Gc$&	386	5	$r	12	43	4
2<$,$k	141	5	$,	13	44	5
2<2k	122	5	$r	7	25	3
N)Fk	187	8	$r	20	50	10
<h$k	366	19	$r	30	102	14
F0$/	191	6	$,	21	70	6
BG$D	160	11	$r	23	55	12
F0;lEv$j J?6Q	180.4	8.3	—	16.2	50.2	7.2
8l5AEv$j J?6Q	25.0	—	—	2.2	7.0	—

!JF0;l 19 8DN&$A!"<g$J 12 8D$rH4?h!#MQNc?t$JINF0;lEv$jJ?6
5AEv$jJ?6Q$OF0;l 19 8D$NJ?6QCM!#!K

3J%U%l!<%`<-=q3MF@$N<jK!

F0;l!VGc$&!W$N8l5A ⟹ *a.*!V6bA,GbNJIr dj<hj9$k!
b.!V$"$kIT2w$J46>p$r0z$-5/$3$

⇓

a. $N0UL#$NNc
!VEZCOrGc&!W, !V3trGc&!W, !V;~7WrGc&!
!V?)NHrGc&!W ...

b. $N0UL#$NNc
!VITI>rGc&!W, !VE\$jrGc&!W, !VH?46rGc
!V<:>PrGc&!W ...

⇓

!VGc$&!W$NB?5A@-$rN`JL$9$k>l9g$K$O!"
!V$r!W3J$G78$kL>;l$N0UL#$K4p$E1PNI$$!

⇓

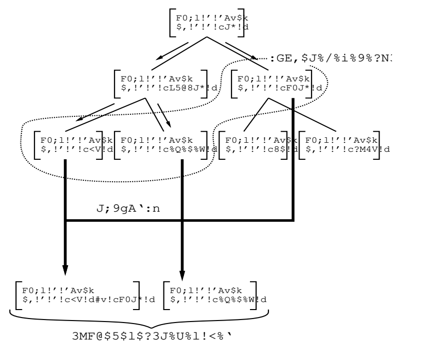
$"$k#18D$NFCDj$N3JMWAG$N0UL#%/%i%9$K
CmL\$7$F!"F0;l$NMQNc=89g$N%/%i%9%?%j%s%
9T$&$3HrDs0F!#

3J%U%l!<%`8uJd$NA*Br!&A`:n$N<j=g

!| $"$kF0;lKD$$$F!"B?5A@-N`JL$K:G$bE,@Z$J<43J$
A*Br9k!#
!| $=$N<43J$N%/%i%9%?%j%s%07k2L$N3,AX$NLZ9=B$$rC
$,$i!":GE,$J%/%i%9%?$NN3EY$r5a$a$k!#
!| :GE,$J%/%i%9%?$K$D$$$F!"F1$88l5A$N3J%U%l!<%`$
$KJ;9g$9$k!#

⇓

Nc!'F0;l!VAv$k!W$NMQNc$r!V9bB.$KJ*$,F0$/!W!VJ*$,@
1dSk!W$H$$$&8l5A$KN`JL$9$k!#



<B83$N9M;!

1. #18D$N<43J$KCmL\$9k3HKhj!"F0;l$N8l5A$NN
   35$M2DG=!#
2. !V$+$+$k!W!V0z$/!W!VD%$k!WEy$NF0;l$O!"J#?t$N<43
   MW!#
3. F0;l$N8l5A?t$, 5 !A 6 8DDxEYJi$P!"3J%U%l!<%`3M
   Hf3SE*MF0W!#
   ⟹ 10 8D0J>eGO!"N3EYA*Br8e$N%/%i%9%??t$,B?$/$
   <j4V$,A}$($k!#
4. 3J%U%l!<%`$NHF2=%l%Y%k$N7hDjH=CG$r!"F0;l$N8l5
   9kFsCME*$JH=CG$K5"CeG-$?!#