bunch

set

string

list

bunch	unpackaged	unindexed
set		
string		
list		

bunch	unpackaged	unindexed
set	packaged	unindexed
string		
list		

bunch	unpackaged	unindexed
set	packaged	unindexed
string	unpackaged	indexed
list		

bunch	unpackaged	unindexed
set	packaged	unindexed
string	unpackaged	indexed
list	packaged	indexed

Bunch Theory

Bunches can be used to represent collections.

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ "a"

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ "a" 2

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ “a” 2

↑

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5, \text{“a”}$ 2

$\uparrow$

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ "a" 2

↑

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ "a" 2

Any number, character, binary, or set is an **elementary bunch**, or **element**.

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ "a" 2

Any number, character, binary, or set is an **elementary bunch**, or **element**.

$A\ ,B$ union

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ "a" 2

Any number, character, binary, or set is an **elementary bunch**, or **element**.

$A\ ,\ B$	union
$A\ \text{‘}\ B$	intersection

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5,$ “a” 2

Any number, character, binary, or set is an **elementary bunch**, or **element**.

A , B	union
$A ‘ B$	intersection
$¢A$	size, cardinality (number)

Bunch Theory

Bunches can be used to represent collections.

$1, 3, 7$ $\top, \bot, 5, \text{"a"}$ 2

Any number, character, binary, or set is an **elementary bunch**, or **element**.

A , B	union
$A \text{ ‘ } B$	intersection
$¢A$	size, cardinality (number)
$A: B$	inclusion (binary)

Bunch Theory

Bunch Theory

$$1, 3, 7 \quad = \quad 3, 1, 7, 1$$

Bunch Theory

$$1, 3, 7 \;=\; 3, 1, 7, 1$$

$$¢2 \;=\; 1$$

$$¢(1, 3, 7) \;=\; 3$$

Bunch Theory

$$1, 3, 7 \;=\; 3, 1, 7, 1$$

$$¢2 \;=\; 1$$

$$¢(1, 3, 7) \;=\; 3 \;=\; ¢(3, 1, 7, 1)$$

Bunch Theory

$1, 3, 7 \;=\; 3, 1, 7, 1$

$¢2 \;=\; 1$

$¢(1, 3, 7) \;=\; 3 \;=\; ¢(3, 1, 7, 1)$

$2\colon\; 0, 2, 5, 9$

Bunch Theory

$1, 3, 7 \;=\; 3, 1, 7, 1$

$¢2 \;=\; 1$

$¢(1, 3, 7) \;=\; 3 \;=\; ¢(3, 1, 7, 1)$

$2\!: \; 0, 2, 5, 9$

$2\!: \; 2$

Bunch Theory

$1, 3, 7 \;=\; 3, 1, 7, 1$

$¢2 \;=\; 1$

$¢(1, 3, 7) \;=\; 3 \;=\; ¢(3, 1, 7, 1)$

$2\colon\; 0, 2, 5, 9$

$2\colon\; 2$

$2, 9\colon\; 0, 2, 5, 9$

Bunch Theory

axioms

$x: y \;=\; x=y$	elementary axiom
$x: A,B \;=\; x: A \lor x: B$	compound axiom
$A,A = A$	idempotence
$A,B = B,A$	symmetry
$A,(B,C) = (A,B),C$	associativity
$A‘A = A$	idempotence
$A‘B = B‘A$	symmetry
$A‘(B‘C) = (A‘B)‘C$	associativity
$A,B: C \;=\; A: C \land B: C$	antidistributivity
$A: B‘C \;=\; A: B \land A: C$	distributivity
$A: A,B$	generalization
$A‘B: A$	specialization

Bunch Theory

axioms

→	$x: y \;=\; x=y$	elementary axiom
	$x: A,B \;=\; x: A \vee x: B$	compound axiom
	$A,A = A$	idempotence
	$A,B = B,A$	symmetry
	$A,(B,C) = (A,B),C$	associativity
	$A`A = A$	idempotence
	$A`B = B`A$	symmetry
	$A`(B`C) = (A`B)`C$	associativity
	$A,B: C \;=\; A: C \wedge B: C$	antidistributivity
	$A: B`C \;=\; A: B \wedge A: C$	distributivity
	$A: A,B$	generalization
	$A`B: A$	specialization

Bunch Theory

axioms

	$x: y \;=\; x=y$	elementary axiom
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	$A`A = A$	idempotence
	$A`B = B`A$	symmetry
	$A`(B`C) = (A`B)`C$	associativity
	$A,B: C \;=\; A: C \land B: C$	antidistributivity
	$A: B`C \;=\; A: B \land A: C$	distributivity
	$A: A,B$	generalization
	$A`B: A$	specialization

Bunch Theory

axioms

	$x: y \;=\; x=y$	elementary axiom
	$x: A,B \;=\; x: A \lor x: B$	compound axiom
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	$A,B = B,A$	symmetry
	$A,(B,C) = (A,B),C$	associativity
	$A`A = A$	idempotence
	$A`B = B`A$	symmetry
	$A`(B`C) = (A`B)`C$	associativity
	$A,B: C \;=\; A: C \land B: C$	antidistributivity
	$A: B`C \;=\; A: B \land A: C$	distributivity
	$A: A,B$	generalization
	$A`B: A$	specialization

Bunch Theory

axioms

	$x\colon y \;=\; x{=}y$	elementary axiom
	$x\colon A{,}B \;=\; x\colon A \;\vee\; x\colon B$	compound axiom
	$A{,}A = A$	idempotence
→	$A{,}B = B{,}A$	symmetry
	$A{,}(B{,}C) = (A{,}B){,}C$	associativity
	$A\text{‘}A = A$	idempotence
	$A\text{‘}B = B\text{‘}A$	symmetry
	$A\text{‘}(B\text{‘}C) = (A\text{‘}B)\text{‘}C$	associativity
	$A{,}B\colon C \;=\; A\colon C \;\wedge\; B\colon C$	antidistributivity
	$A\colon B\text{‘}C \;=\; A\colon B \;\wedge\; A\colon C$	distributivity
	$A\colon A{,}B$	generalization
	$A\text{‘}B\colon A$	specialization

Bunch Theory

axioms

	x: y = x=y	elementary axiom
	x: A,B = x: A ∨ x: B	compound axiom
	A,A = A	idempotence
	A,B = B,A	symmetry
→	A,(B,C) = (A,B),C	associativity
	A‘A = A	idempotence
	A‘B = B‘A	symmetry
	A‘(B‘C) = (A‘B)‘C	associativity
	A,B: C = A: C ∧ B: C	antidistributivity
	A: B‘C = A: B ∧ A: C	distributivity
	A: A,B	generalization
	A‘B: A	specialization

Bunch Theory

axioms

Bunch Theory

axioms

$A: A$	reflexivity
$A: B \ \wedge \ B: A \ = \ A{=}B$	antisymmetry
$A: B \ \wedge \ B: C \ \Rightarrow \ A: C$	transitivity
$¢x \ = \ 1$	size
$¢(A,B) + ¢(A‘B) \ = \ ¢A + ¢B$	size
$\neg \ x: A \ \Rightarrow \ ¢(A‘x) = 0$	size
$A: B \ \Rightarrow \ ¢A \le ¢B$	size

Bunch Theory

axioms

→	$A: A$	reflexivity
→	$A: B \land B: A \;=\; A=B$	antisymmetry
→	$A: B \land B: C \;\Rightarrow\; A: C$	transitivity
	$¢x \;=\; 1$	size
	$¢(A,B) + ¢(A`B) \;=\; ¢A + ¢B$	size
	$\neg\, x: A \;\Rightarrow\; ¢(A`x) = 0$	size
	$A: B \;\Rightarrow\; ¢A \le ¢B$	size

Bunch Theory

Bunch Theory

laws

$A,(A\text{‘}B) \;=\; A$	absorption
$A\text{‘}(A,B) \;=\; A$	absorption
$A: B \;\Rightarrow\; C,A: C,B$	monotonicity
$A: B \;\Rightarrow\; C\text{‘}A: C\text{‘}B$	monotonicity
$A: B \;=\; A,B = B \;=\; A = A\text{‘}B$	inclusion
$A,(B,C) \;=\; (A,B),(A,C)$	distributivity
$A,(B\text{‘}C) \;=\; (A,B)\text{‘}(A,C)$	distributivity
$A\text{‘}(B,C) \;=\; (A\text{‘}B), (A\text{‘}C)$	distributivity
$A\text{‘}(B\text{‘}C) \;=\; (A\text{‘}B)\text{‘}(A\text{‘}C)$	distributivity
$A: B \;\wedge\; C: D \;\Rightarrow\; A,C: B,D$	conflation
$A: B \;\wedge\; C: D \;\Rightarrow\; A\text{‘}C: B\text{‘}D$	conflation

Bunch Theory

laws

	$A,(A`B) = A$	absorption
	$A`(A,B) = A$	absorption
→	$A: B \Rightarrow C,A: C,B$	monotonicity
→	$A: B \Rightarrow C`A: C`B$	monotonicity
	$A: B \;=\; A,B = B \;=\; A = A`B$	inclusion
	$A,(B,C) = (A,B),(A,C)$	distributivity
	$A,(B`C) = (A,B)`(A,C)$	distributivity
	$A`(B,C) = (A`B), (A`C)$	distributivity
	$A`(B`C) = (A`B)`(A`C)$	distributivity
	$A: B \wedge C: D \Rightarrow A,C: B,D$	conflation
	$A: B \wedge C: D \Rightarrow A`C: B`D$	conflation

Bunch Theory

Bunch Theory

null			the empty bunch
bin	=	$\top, \bot$	the binary values
nat	=	$0, 1, 2, ...$	the natural numbers
int	=	$..., -2, -1, 0, 1, 2, ...$	the integer numbers
rat	=	$..., -1, 0, 2/3, ...$	the rational numbers
real	=	$..., 2^{1/2}, ...$	the real numbers
xnat	=	$0, 1, 2, ..., \infty$	the extended natural numbers
xint	=	$-\infty, ..., -2, -1, 0, 1, 2, ..., \infty$	the extended integer numbers
xrat	=	$-\infty, ..., -1, 0, 2/3, ..., \infty$	the extended rational numbers
xreal	=	$-\infty, ..., \infty$	the extended real numbers
char	=	..., “a”, “A”, ...	the character values

Bunch Theory

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bin	=	$\top, \bot$	the binary values
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rat	=	..., –1, 0, 2/3, ...	the rational numbers
→ *real*	=	..., $2^{1/2}$, ...	the real numbers
xnat	=	0, 1, 2, ..., ∞	the extended natural numbers
xint	=	–∞, ..., –2, –1, 0, 1, 2, ..., ∞	the extended integer numbers
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Bunch Theory

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	int	=	..., –2, –1, 0, 1, 2, ...	the integer numbers
	rat	=	..., –1, 0, 2/3, ...	the rational numbers
	real	=	..., $2^{1/2}$, ...	the real numbers
→	*xnat*	=	0, 1, 2, ..., ∞	the extended natural numbers
→	*xint*	=	–∞, ..., –2, –1, 0, 1, 2, ..., ∞	the extended integer numbers
→	*xrat*	=	–∞, ..., –1, 0, 2/3, ..., ∞	the extended rational numbers
→	*xreal*	=	–∞, ..., ∞	the extended real numbers
	char	=	..., “a”, “A”, ...	the character values

Bunch Theory

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rat	=	..., –1, 0, 2/3, ...	the rational numbers
real	=	..., $2^{1/2}$, ...	the real numbers
xnat	=	0, 1, 2, ..., ∞	the extended natural numbers
xint	=	–∞, ..., –2, –1, 0, 1, 2, ..., ∞	the extended integer numbers
xrat	=	–∞, ..., –1, 0, 2/3, ..., ∞	the extended rational numbers
xreal	=	–∞, ..., ∞	the extended real numbers
→ *char*	=	..., “a”, “A”, ...	the character values

Bunch Theory

$x,..y$

Bunch Theory

$x,..y$ “ x to y ”

Bunch Theory

$x,..y$ "x to y" for $x \le y$

Bunch Theory

$x,..y$

Bunch Theory

$i: x,..y \quad = \quad x \le i < y$

Bunch Theory

$i: x,..y \quad = \quad x \le i < y$

$¢(x,..y) \quad = \quad y–x$

Bunch Theory

$$i: x,..y \quad = \quad x \le i < y$$

$$¢(x,..y) \quad = \quad y–x$$

$$0,..3 \quad = \quad 0, 1, 2$$

Bunch Theory

$i: x,..y \quad = \quad x \le i < y$

$¢(x,..y) \quad = \quad y - x$

$0,..3 \quad = \quad 0, 1, 2$

$0,..2 \quad = \quad 0, 1$

Bunch Theory

$i: x,..y \quad = \quad x \le i < y$

$¢(x,..y) \quad = \quad y–x$

$0,..3 \quad = \quad 0, 1, 2$

$0,..2 \quad = \quad 0, 1$

$0,..1 \quad = \quad 0$

Bunch Theory

$i: x,..y \quad = \quad x \le i < y$

$¢(x,..y) \quad = \quad y – x$

$0,..3 \quad = \quad 0, 1, 2$

$0,..2 \quad = \quad 0, 1$

$0,..1 \quad = \quad 0$

$0,..0 \quad = \quad null$

Bunch Theory

$i: x,..y \quad = \quad x \le i < y$

$¢(x,..y) \quad = \quad y–x$

$0,..3 \quad = \quad 0, 1, 2$

$0,..2 \quad = \quad 0, 1$

$0,..1 \quad = \quad 0$

$0,..0 \quad = \quad null$

$0,..\infty \quad = \quad nat$

Bunch Theory

distribution

Bunch Theory

distribution

$$-(1, 3, 7) = -1, -3, -7$$

Bunch Theory

distribution

$$-(1, 3, 7) \; = \; -1, -3, -7$$

$$(1, 2) + (10, 20) \; = \; 11, 12, 21, 22$$

Bunch Theory

distribution

$$-(1, 3, 7) = -1, -3, -7$$

$$(1, 2) + (10, 20) = 11, 12, 21, 22$$

$$(1, 2) + 10 = 11, 12$$

Bunch Theory

distribution

$-(1, 3, 7) \ = \ -1, -3, -7$

$(1, 2) + (10, 20) \ = \ 11, 12, 21, 22$

$(1, 2) + 10 \ = \ 11, 12$

$1 + 10 \ = \ 11$

Bunch Theory

distribution

$$-(1, 3, 7) \; = \; -1, -3, -7$$

$$(1, 2) + (10, 20) \; = \; 11, 12, 21, 22$$

$$(1, 2) + 10 \; = \; 11, 12$$

$$1 + 10 \; = \; 11$$

$$\mathit{null} + 10 \; =$$

Bunch Theory

distribution

$$-(1, 3, 7) \;=\; -1, -3, -7$$

$$(1, 2) + (10, 20) \;=\; 11, 12, 21, 22$$

$$(1, 2) + 10 \;=\; 11, 12$$

$$1 + 10 \;=\; 11$$

$$null + 10 \;=\; null$$

Bunch Theory

distribution

$-(1, 3, 7) \ = \ -1, -3, -7$

$(1, 2) + (10, 20) \ = \ 11, 12, 21, 22$

$(1, 2) + 10 \ = \ 11, 12$

$1 + 10 \ = \ 11$

$null + 10 \ = \ null$

$nat + 2 \ = \ 2, 3, 4, 5, 6, ...$

Bunch Theory

distribution

$$-(1, 3, 7) = -1, -3, -7$$

$$(1, 2) + (10, 20) = 11, 12, 21, 22$$

$$(1, 2) + 10 = 11, 12$$

$$1 + 10 = 11$$

$$null + 10 = null$$

$$nat + 2 = 2, 3, 4, 5, 6, ...$$

$$nat \times 2 = 0, 2, 4, 6, 8, ...$$

Bunch Theory

distribution

$-(1, 3, 7) = -1, -3, -7$

$(1, 2) + (10, 20) = 11, 12, 21, 22$

$(1, 2) + 10 = 11, 12$

$1 + 10 = 11$

$null + 10 = null$

$nat + 2 = 2, 3, 4, 5, 6, ...$

$nat \times 2 = 0, 2, 4, 6, 8, ...$

$nat^2 = 0, 1, 4, 9, 16, ...$

Bunch Theory

distribution

$-(1, 3, 7) = -1, -3, -7$

$(1, 2) + (10, 20) = 11, 12, 21, 22$

$(1, 2) + 10 = 11, 12$

$1 + 10 = 11$

$null + 10 = null$

$nat + 2 = 2, 3, 4, 5, 6, ...$

$nat \times 2 = 0, 2, 4, 6, 8, ...$

$nat^2 = 0, 1, 4, 9, 16, ...$

$2^{nat} = 1, 2, 4, 8, 16, ...$

Set Theory

provides nested structure (things within things)

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
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$1, 3, 7$

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"

$\{1, 3, 7\}$

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"

$\{1, 3, 7\}, 8$

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"

$\{\{1, 3, 7\}, 8\}$

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"
$\{\{1, 3, 7\}, 8\}$	
$\{null\}$	the empty set

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"
$\{\{1,3,7\},8\}$	
$\{null\}$	the empty set
$\{nat\}$	the set of natural numbers

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"
$\{\{1, 3, 7\}, 8\}$	
$\{null\}$	the empty set
$\{nat\}$	the set of natural numbers
$\{0, 1, 2\} = \{0,..3\}$	

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"
$\{\{1, 3, 7\}, 8\}$	
$\{null\}$	the empty set
$\{nat\}$	the set of natural numbers
$\{0, 1, 2\} = \{0,..3\}$	
$\sim\{1, 3, 7\} = 1, 3, 7$	contents

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"
$\{\{1, 3, 7\}, 8\}$	
$\{null\}$	the empty set
$\{nat\}$	the set of natural numbers
$\{0, 1, 2\} = \{0,..3\}$	
$\sim\{1, 3, 7\} = 1, 3, 7$	contents
$\$\{1, 3, 7\} = 3$	size, cardinality

Set Theory

provides nested structure (things within things)

$\{A\}$	"set containing A"
$\sim S$	"contents of S"
$\{\{1, 3, 7\}, 8\}$	
$\{null\}$	the empty set
$\{nat\}$	the set of natural numbers
$\{0, 1, 2\} = \{0,..3\}$	
$\sim\{1, 3, 7\} = 1, 3, 7$	contents
$\$\{1, 3, 7\} = 3$	size, cardinality
$\not{2}(0, 1) = \{null\}, \{0\}, \{1\}, \{0, 1\}$	power

Set Theory

axioms

$$\{\sim S\} = S$$

$$\sim\{A\} = A$$

$$\{A\} \mp A$$

$$\$\{A\} = ¢A$$

$$A \in \{B\} = A : B$$

$$\{A\} \subseteq \{B\} = A : B$$

$$\{A\} : \lightning B = A : B$$

$$\{A\} \cup \{B\} = \{A, B\}$$

$$\{A\} \cap \{B\} = \{A \text{‘} B\}$$

$$\{A\} = \{B\} = A = B$$

Set Theory

axioms

$\{\sim S\} = S$

$\sim\{A\} = A$

→ $\{A\} \mp A$

$\$\{A\} = ¢A$

$A \in \{B\} \;=\; A : B$

$\{A\} \subseteq \{B\} \;=\; A : B$

$\{A\} : ↯B \;=\; A : B$

$\{A\} \cup \{B\} = \{A, B\}$

$\{A\} \cap \{B\} = \{A ‘ B\}$

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Set Theory

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$\rightarrow$ $A \in \{B\} = A : B$

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$\{A\} = \{B\} = A = B$