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\[ n = (x)((x)(x)) \]

which forms constant function:

\[ f = (f) \]

The identity operator:

\[ ((x)f)(y) = (x)((x)f)(y) \]

A reversed composition operator:

\[ ((x)f)(y) = (x)((y)f)(y) \]

which compose two functions:

\[ (x)f = (x)((x)(x)) \]

Operations are the following:

The operator \( C \) may be called a **combinator**; other examples of such

\[ A(x)C = A \]

Then the commutative law becomes simply

\[(x'y)f(x')f = (y'x)(f)(C)\]

And then introduce an operator \( D \) defined by

\[ (x'y)f = (y'x)A \]

For all \( x' \), \( y' \), \( x \), \( y \), and other variables, such as \( a \), \( b \), \( c \), \( d \), \( e \), and \( f \).

The above expression contains bound variables, \( x \), \( y \), and \( a \).

In mathematics, which says

To introduce combinators, consider the commutative law of addition

Advantages we shall have to decide the intuitive clarity of the \( x \)-function.

However, for this eventual succeeds completely in the present chapter. Therefore, for this eventual succeeds completely in the present chapter. However, for this eventual succeeds completely in the present chapter. However, for this eventual succeeds completely in the present chapter.

In fact, the number of combinators are defined to do the same work as systems

2 An Introduction to C. L

**Combinatory Logic**

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Example 2.7

Given a definition of $\Omega$ by induction

$a^* \in \Omega$ for all $a$.

$\Omega$ is an algebraic signature if $\Omega$ is a set of symbols and $\Omega$ is a set of赖以生存的

Definition 2.6 (Substitution)

$x \in \mathcal{A}$ implies that $\mathcal{A}$ occurs in $\mathcal{A}$.

Substitution of $x$ in $\mathcal{A}$ is defined to be the result of

$x \in \mathcal{A}$.

For every occurrence of $x$ in $\mathcal{A}$, the result of substituting $x$ for $x$ is $\mathcal{A}[x/x]$.

Example 2.6 Let $\mathcal{A} \in \Omega$ and $x \in \mathcal{A}$. Then $\mathcal{A}[x/x]$ occurs in $\mathcal{A}$.

The set of all variables occurring in $\mathcal{A}$ is called $\mathcal{P}(\mathcal{A})$.

Examples 2.7 Let $\mathcal{A} \in \Omega$ and $x \in \mathcal{A}$. Then $\mathcal{A}[x/x]$ occurs in $\mathcal{A}$.

Definition 2.4 (Substitution)

For example, let $\mathcal{A} \in \Omega$ and $x \in \mathcal{A}$. Then $\mathcal{A}[x/x]$ occurs in $\mathcal{A}$.

Theorem 2.5

Definition 2.3 (Combinatory Logic Terms)

$\mathcal{K}$ and $\mathcal{S}$ are $\mathcal{C}$.

Theorem 2.6

Definition 2.2 (Combinatory Logic Terms)

$\mathcal{K}$ and $\mathcal{S}$ are $\mathcal{C}$.

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Definition 2.2 (Combinatory Logic Terms)

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Definition 2.10 A weak normal form of a term $\xi$ is a term $\xi'$ in which all occurrences of weak contractions, if they appear, are preceded by a fresh variable symbol.

Lemma 2.11 (Substitution Lemma) For $\xi, \eta, \alpha \in K$.

Example 2.12 (Weak Reduction) $$(\xi)$$

Example 2.13 (Commutative logic)

Theorem 2.12 (Church-Rosser) For $\xi, \eta \in K$.

Proof (c) $\xi = \alpha\eta$ such that $\xi$, $\eta$, and $\alpha \eta$ are in $\xi$.

Corollary 2.13 (Uniqueness of nf) A $\xi$-term can have at most

$\xi$-terms $X$, $Y$, and $Z$.

Definition 2.11 Define $\xi = \xi'$.

Theorem 2.12 (Church-Rosser) For $\xi, \eta \in K$.

Proof (c) $\xi = \alpha\eta$ such that $\xi$, $\eta$, and $\alpha \eta$ are in $\xi$.

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Corollary 2.13 (Uniqueness of nf) A $\xi$-term can have at most

$\xi$-terms $X$, $Y$, and $Z$.
proof by induction on the structure of $\Lambda$. For all $x$, we shall prove that $x \notin \text{CL}$.

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The class in this proof is that if $x$ is not a CL-term, then $x$ is not a CL-term.

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For all $x$, we shall prove that $x \notin \text{CL}$.
\[ \lambda^{x/\alpha} = \lambda^{x/\beta} \iff \lambda^{x}_\alpha = \lambda^{x}_\beta \]

**Lemma 2.31.**

**Exercise 2.30.** Prove that if \( B, W \) are the terms in Example 2.12 and

\[ B \equiv X, \quad W \equiv Y \]

then

\[ (\lambda^{x/\alpha} + \lambda^{y/\beta}) \equiv (\lambda^{x/\alpha} + \lambda^{y/\beta}) \]

is a weak equid of \( \lambda^{x/\alpha} \) or \( \lambda^{y/\beta} \) such that

\[ \lambda^{x/\alpha} \equiv \lambda^{x/\alpha} \quad \text{and} \quad \lambda^{y/\beta} \equiv \lambda^{y/\beta} \]

is a weak equid of \( \lambda^{x/\alpha} \) or \( \lambda^{y/\beta} \). That is, \( \lambda^{x/\alpha} \) or \( \lambda^{y/\beta} \) is a weak equid of \( \lambda^{x/\alpha} \) or \( \lambda^{y/\beta} \).

**Note:**

The last two results have shown that if \( \lambda \) has similar properties to

\[ \lambda \equiv \lambda \]

for all variables \( x \), then | traverse induction on \( \lambda \).

**Proof.** Strongly upwards induction on \( \lambda \).

\[ (\lambda^x \varphi) \beta \equiv \beta \]

**Definition 2.29.** (Weak equid of \( \lambda \))

**Lemma 2.32.** (Weak equid of \( \lambda \))

**Theorem 2.32.** (Weak equid of \( \lambda \))

\[ \lambda \equiv \lambda \]

**Exercise 2.31.** Prove that if \( B, W \) are the terms in Definition 2.12 then the equid of \( \lambda \) with \( \lambda \) is equal to the equid of \( \lambda \) with \( \lambda \). Note that

\[ \lambda \equiv \lambda \]

**Example 2.18.**

\[ \lambda \equiv \lambda \]

**Remark 2.33.** There are other possible definitions of equid.
Exercise 2.26

There are an action with an action-state (Contrast with calculus 2.23).

Show that this would be false if respect to weak reduction. It's that there is a normal form.

(6) Proof that a term X is in weak normal form if X is normal with

(7) Operations involving decisions that depend on the state.

\( A \equiv X \) if for some N, X

\( \Lambda X \equiv X \) if \( X = X \)

\( S = X \)

The action and normal form. Le show that there is no such

(8) Construct a pairing-combinator \( d \) and two projections \( d', d'' \)

* Exercise 2.34

will be discussed in Chapter 3.

new axioms to weak equality to make it stronger. Possible extra axioms

weak \( X(\alpha) = X(\beta) \) is no longer an operation in the sense of weak equality. This is still

the case for all the axioms of weak equality. This is especially

For many purposes the lack of (6) is no problem and the simplicity

These are normal forms and distinct, so by 2.22 they are not weakly

\( \Lambda X \equiv X \) if for some N, X

\( \Lambda X \equiv X \) if \( X = X \)

\( S = X \)

Although the above results show that \( m \) is a normal form.

Corollary 2.32.4 (Uniqueness of m) A term can be weakly equal to

call all terms are weakly equal.

These are normal forms. Here both have the same weak normal form.

Corollary 2.32.2 If \( X \) and \( Y \) are different weak normal forms, then

there exists a term S such that

Corollary 2.32.1 X is a weak equal, then \( X = \Lambda \) if and only if X

Proof From 2.19, the proof of 1.14 from 1.32.

then \( X = \Lambda = \Lambda \) if and only if \( X = \Lambda \).
Definition 3.2 A combinator is a term of the form $\text{A} \sigma \text{B}$, \( \sigma \in \{\text{C}, \text{B}, \text{W}, \text{K}, \text{S} \} \), where $\text{A}$ and $\text{B}$ are terms, and $\text{C}, \text{B}, \text{W}, \text{K}, \text{S}$ are operators. (In QL, $\text{A}$ is a closed pure term, i.e., a term containing neither free variables nor atomic constants.)

Notation 3.1 The chapter is written in a neutral notation, which may be interpreted in either of QL, as follows:

Historical comments to the end of chapters (Section GM) show why reduction (Section GA) and intersection of partial combinators (Chapter 7) will be discussed in Section 3.4. The chapter 4 will show that all recursive functions are definable in just interpretable formal systems. After those results, Section 3.5 will outline the history of QL and QL'.

The purpose of this chapter and the next two is to show some of the power of the combinator and the next two to show some of the power of the combinator.

Further Reading

- [Example 3.19. (C)]
- \( \text{B}(\text{W})(\text{B})(\text{B}) \)
- \( \text{B} \)
- \( \text{E} \)
- \( \text{B} \text{(E)} \text{(C)} \text{(B)} \text{(B)} \)
- \( \text{B} \text{(W)} \text{(E)} \text{(C)} \text{(B)} \text{(B)} \)
- \( \text{B} \text{(E)} \text{(C)} \text{(B)} \text{(B)} \)