Funcalc

A Spreadsheet Research Prototype

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Outline

Introduction

Sheet-defined Functions

Functional Paradigms In Spreadsheets

Dataflow Computation

Overview of Funcalc

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- 2 PhDs, 2 student programmers

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- Complex models in biology, physics, economy, finance etc.

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- Compute s in column `D`

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7	a	b	c	s	area
8	3	4	5	=(A8+B8+C8)/2	=SQRT(D8*(D8-A8)*(D8-B8)*(D8-C8))
9	30	40	50	=(A9+B9+C9)/2	=SQRT(D9*(D9-A9)*(D9-B9)*(D9-C9))
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- Even more verbose if we exclude intermediate computations

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  - ↳ Errors in million dollar budgets

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"Can you imagine programming in C without procedures, however clever the editor's copy-and-paste technology?" [PBB03]

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1	'Area of ...					
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3	3	4	5	=(A3+B3+C3)/2	=SQRT(D3*(D3-A3)*(D3-B3)*(D3-C3))	
4					=DEFINE("triarea", E3, A3, B3, C3)	
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7	a	b	c	area
8	3	4	5	=TRIAREA(A8;B8;C8)
9	30	40	50	600
10	100	100	100	4330.12701892219

Dual Implementation

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- Function sheets: Rarely edited, frequently evaluated

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- `=MAP(f, [`x_1`, `x_2`, ..., `x_n`])`

Example: A General N-sided Die

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28	=CLOSURE("ndie", 6)	=CLOSURE("ndie", 20)
29	=APPLY(A$28)	=APPLY(B$28)
30	=APPLY(A$28)	=APPLY(B$28)
31	=APPLY(A$28)	=APPLY(B$28)
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33	=APPLY(A$28)	=APPLY(B$28)

28	NDIE(6)	NDIE(20)
29	6	6
30	2	1
31	1	13
32	4	14
33	6	17

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  - Reimplemented other common Excel functions like `GOALSEEK`, `VLOOKUP`, ... [Ses14]
  - Translating 16 SISAL programs to Funcalc [Can]

SDF Performance

Opportunity 1

Function	Excel Built-in (ns)	SDF (ns)
PV	1461	804
FV	1445	1138
NPER	1055	472
RATE	2297	44864
PMT	1523	664
FVSCHEDULE	2960	928
IPMT	1593	1732
PPMT	1805	1292
CUMIPMT	3117	3400
CUMPRINC	2742	4072
ISPMT	468	170

TABLE: Performance of Excel Financial Functions vs. SDFs

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- ✓ Promotes easy sharing as “libraries”
- ✓ High level of expressive power
- ✗ Still need to understand complex concepts such as recursion and closures
- ✗ Currently few debugging tools and general support

★ Demo time! ★

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Function Fusion and Transformation

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  - How to display otherwise?

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  - Optimising compiler for automatically extracting implicit parallelism [Sar89]
    - *Compile-time* partitioning
    - *Runtime* scheduling
  - Ran on par with Fortran on Cray-Y-MP/864 shared-memory multi-core machine

Dataflow

Opportunity 3

- **Motivation:** Parallel Recalculation
- Background:
  - SISAL
    ⇒ **S**treams and **I**terations In A **S**ingle **A**ssignment **L**anguage [Can; McG+85]
  - Functional (first-order) replacement for Fortran in scientific computing
  - Optimising compiler for automatically extracting implicit parallelism [Sar89]
    - *Compile-time* partitioning
    - *Runtime* scheduling
  - Ran on par with Fortran on Cray-Y-MP/864 shared-memory multi-core machine
  - Spreadsheets (dataflow) + (higher-order) SDFs ⇒ SISAL

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  - Spreadsheets (dataflow) + (higher-order) SDFs $\Rightarrow$ SISAL
- **Project idea**: Revisit and modernize Sarkar's work for spreadsheets

Target Audience

Opportunity 3

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- Not your everyday spreadsheet user

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  - Their primary computational model

Target Audience

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- Not your everyday spreadsheet user
- Not HPC communities
- Spreadsheet users with large datasets:
  - Their primary computational model
  - No formal training in IT or programming

Algorithm Outline

Opportunity 3

1. **GR Graph Construction**
2. Cost Assignment
3. Partitioning
4. Task Scheduling

Algorithm Outline

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=IF(A6, B6, C6)*SUM(A1:B2)
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Algorithm Outline

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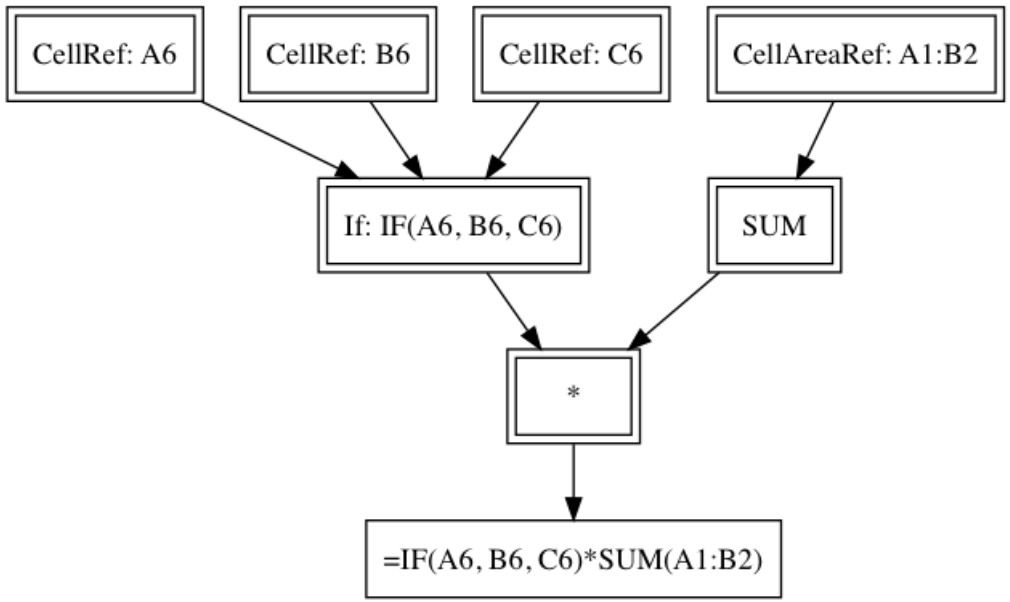

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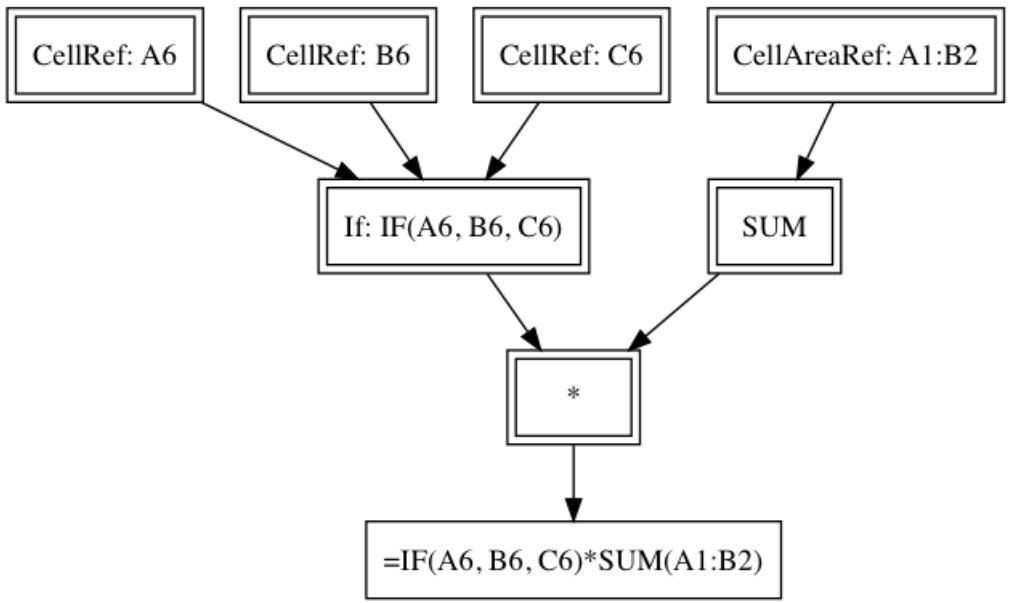

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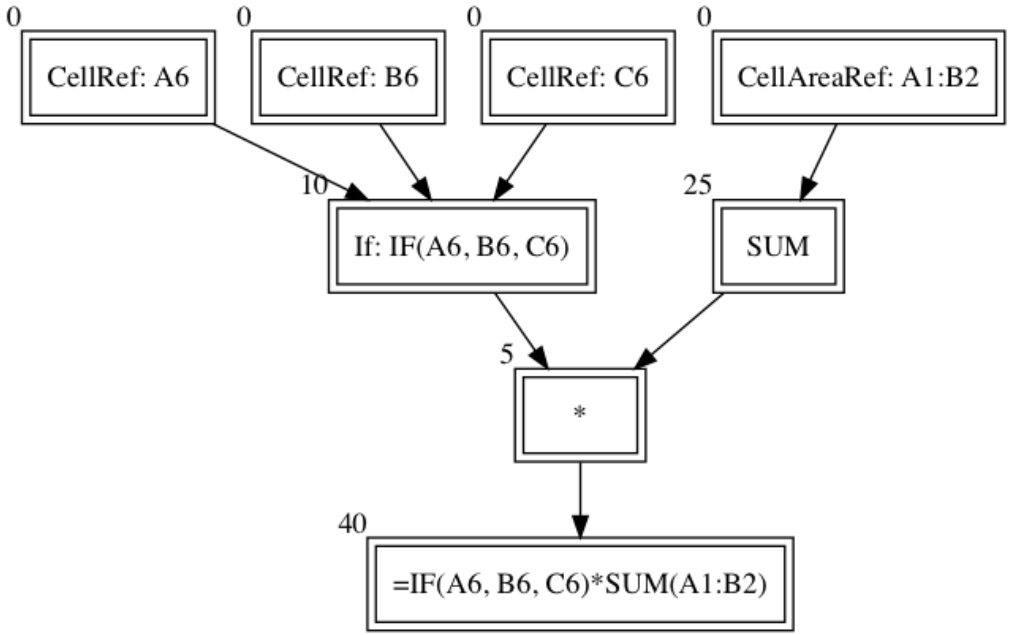

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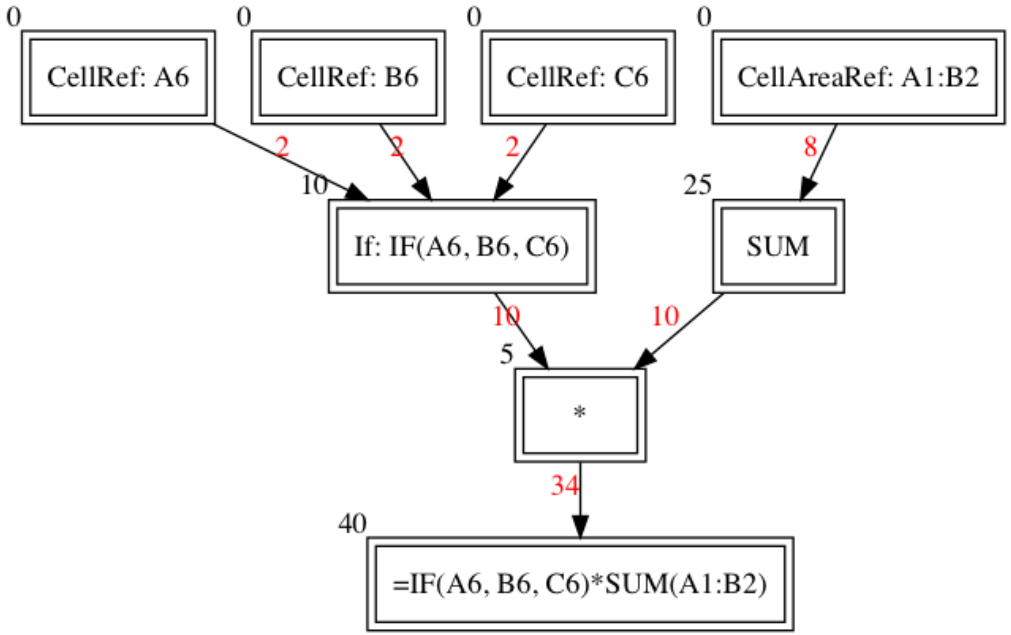

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- Objective function `F` balances:

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- Objective function `F` balances:
  - Communication overhead

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- Objective function `F` balances:
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- Objective function `F` balances:
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- *Fine* partition: Overhead term will dominate

Algorithm Outline

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- Objective function `F` balances:
  - Communication overhead
  - Critical path cost
- *Fine* partition: Overhead term will dominate
- *Coarse* partition: Critical path term will dominate

Algorithm Outline

Opportunity 3

1. GR Graph Construction
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3. **Partitioning (II)**
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1. Partition the graph into task partitions

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1. Partition the graph into task partitions
2. Put all nodes in a task by themselves

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3. Iteratively merge pairs of tasks

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5. Record iteration `i` that minimised an objective function `F`
6. Reconstruct the $\texttt{i}^{th}$ task partition

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- Ensure that task partitions are acyclic

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- Once a task has all inputs

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  $\Rightarrow$ Run to completion

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- Ensure that task partitions are acyclic
- Once a task has all inputs

  $\Rightarrow$ Run to completion
- Will use the Task Parallel Library [Mic; LSB09]

Spreadsheets Are A Different Paradigm

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   - ▸ Spreadsheets have no concept of compile-time
   - ✗ Incurred runtime overhead
   - ✓ Take advantage of runtime information

Other Ongoing Projects

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- Function fusion + anonymous closures

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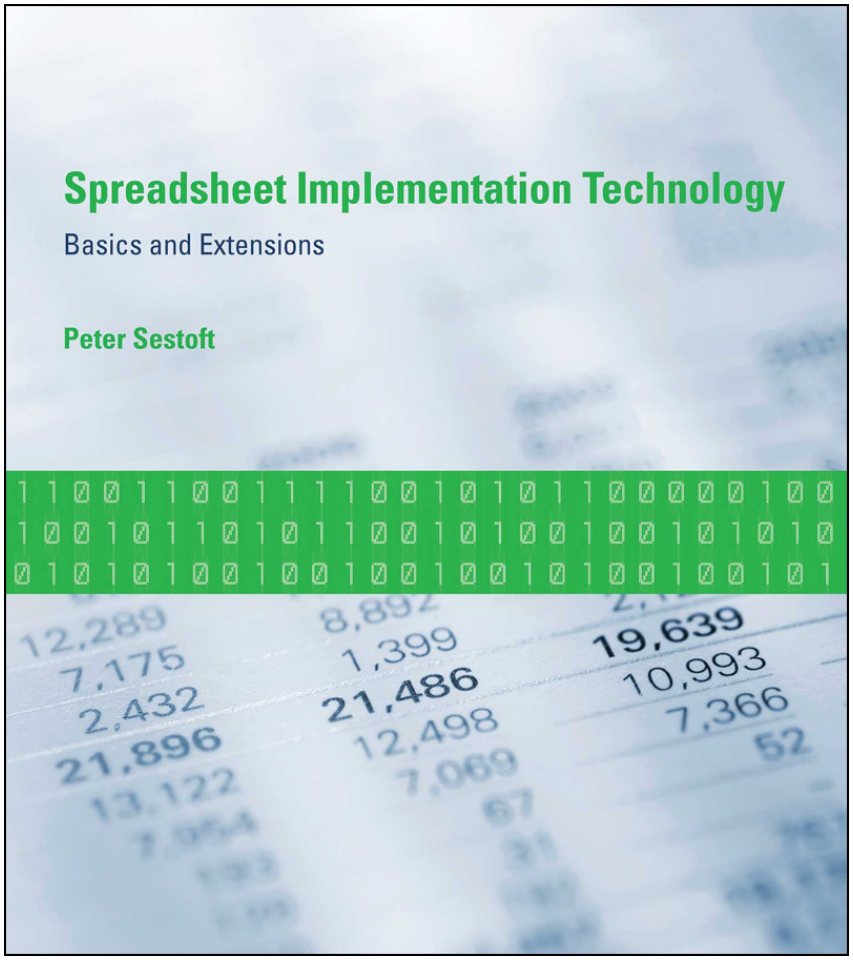

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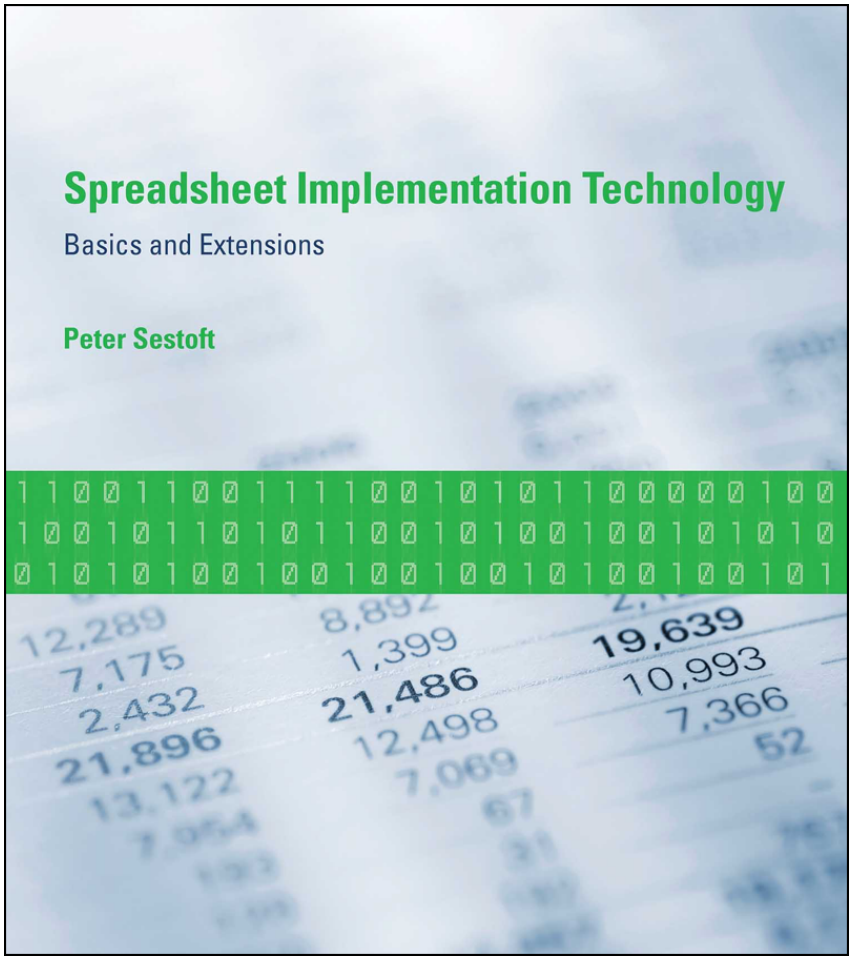

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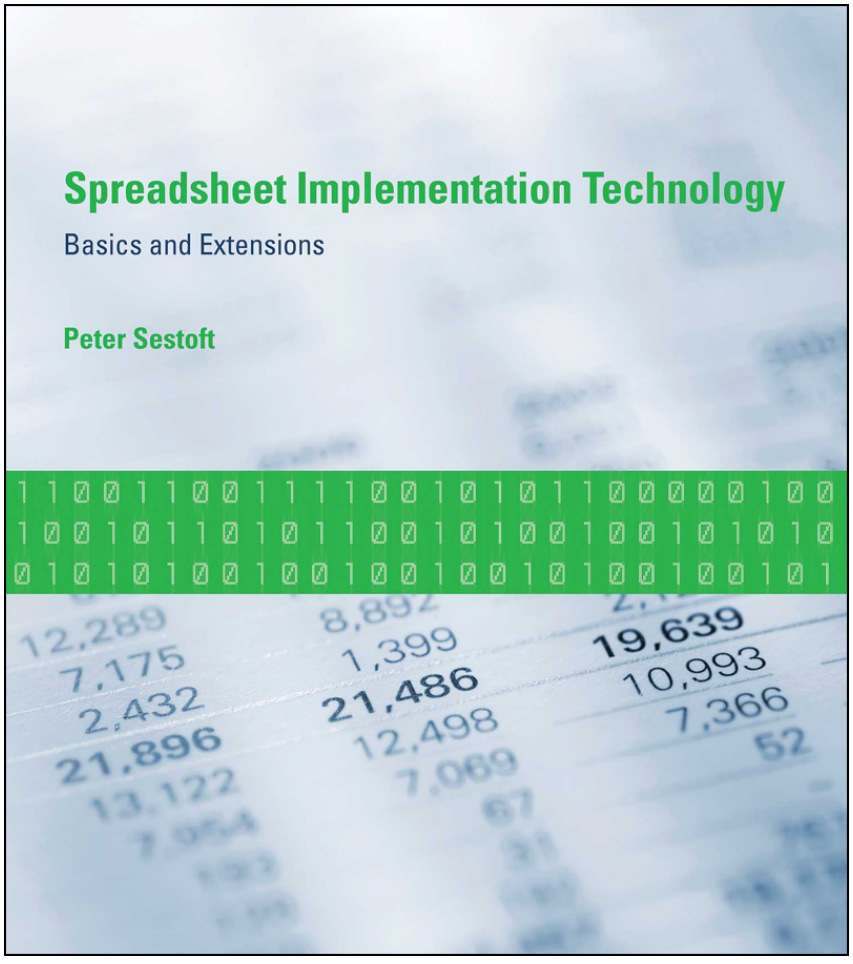

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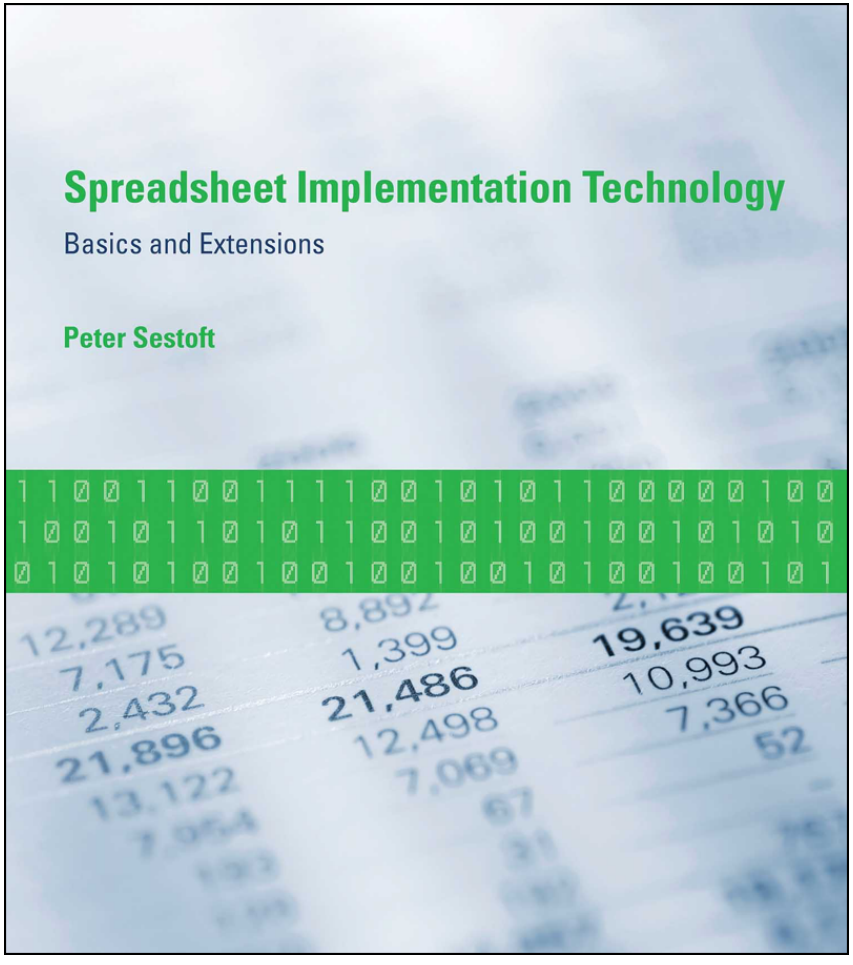

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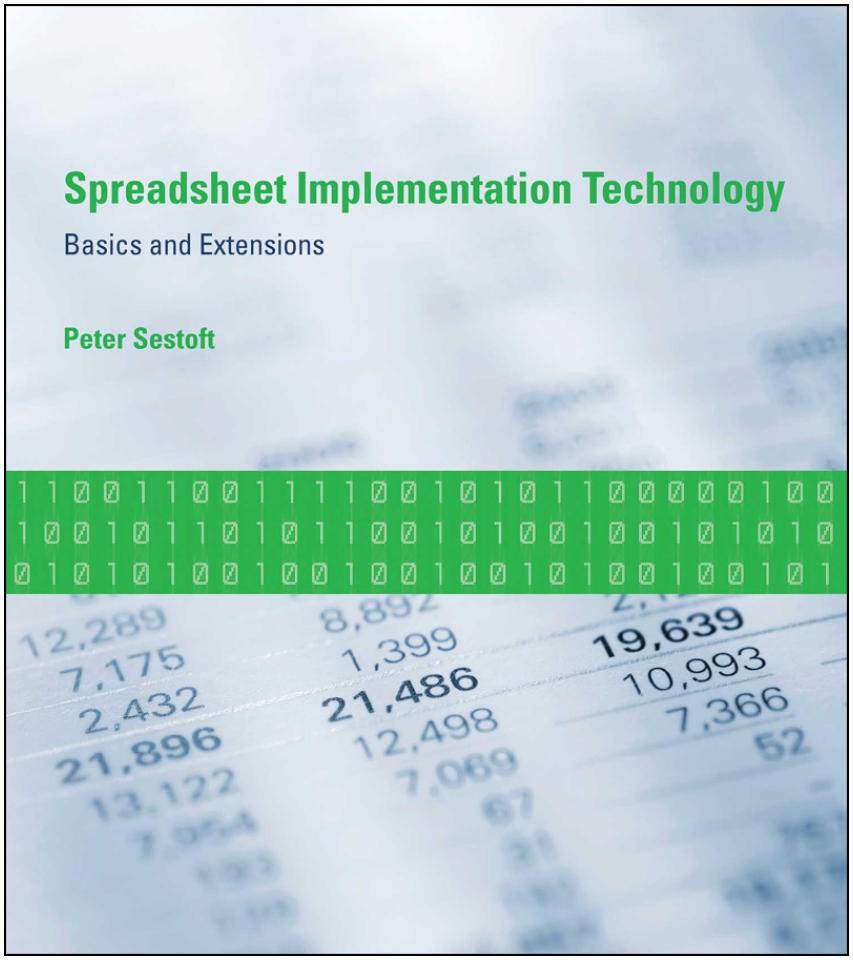

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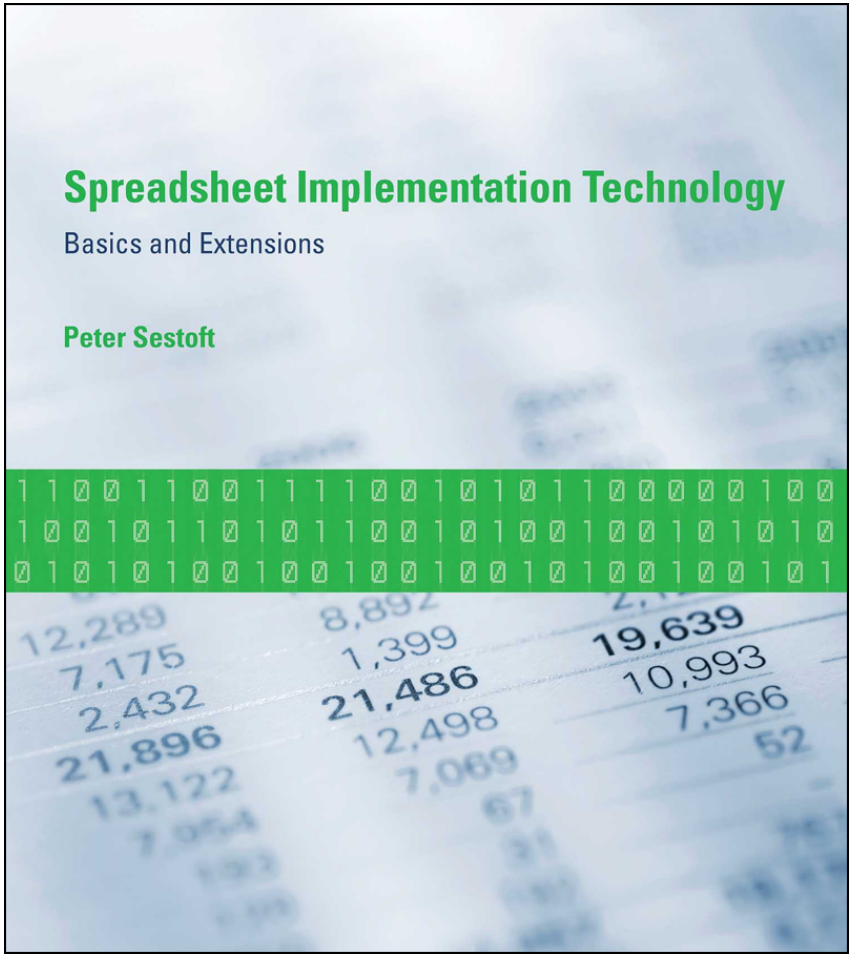

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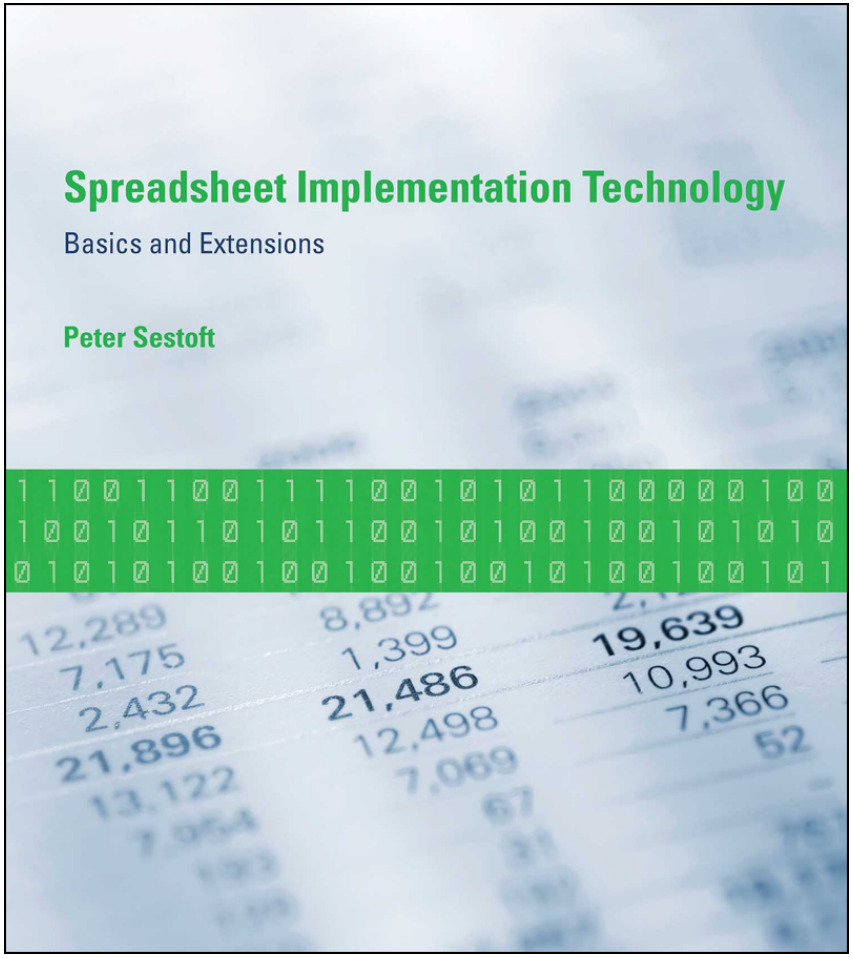

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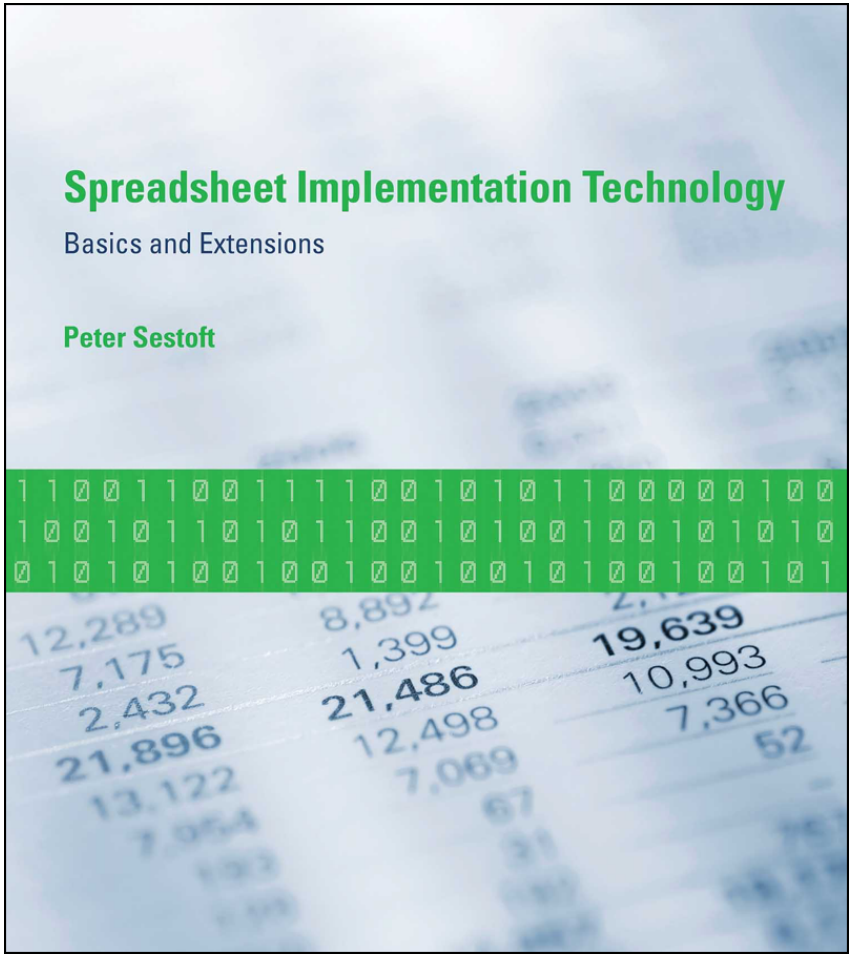

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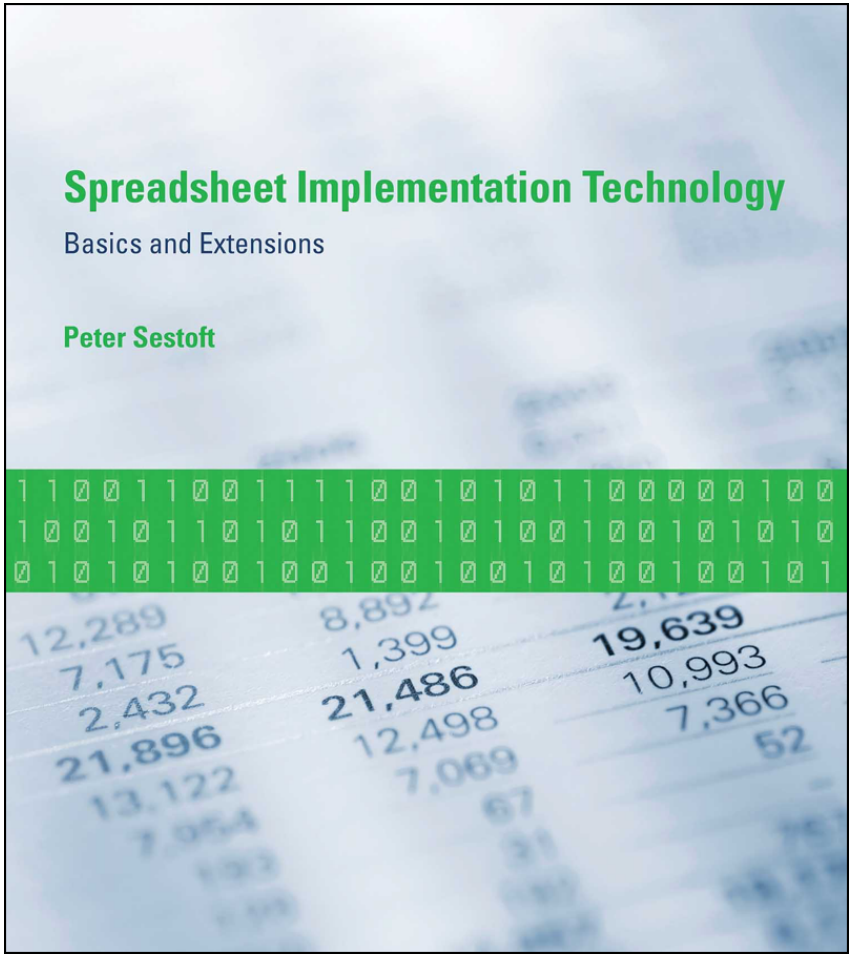

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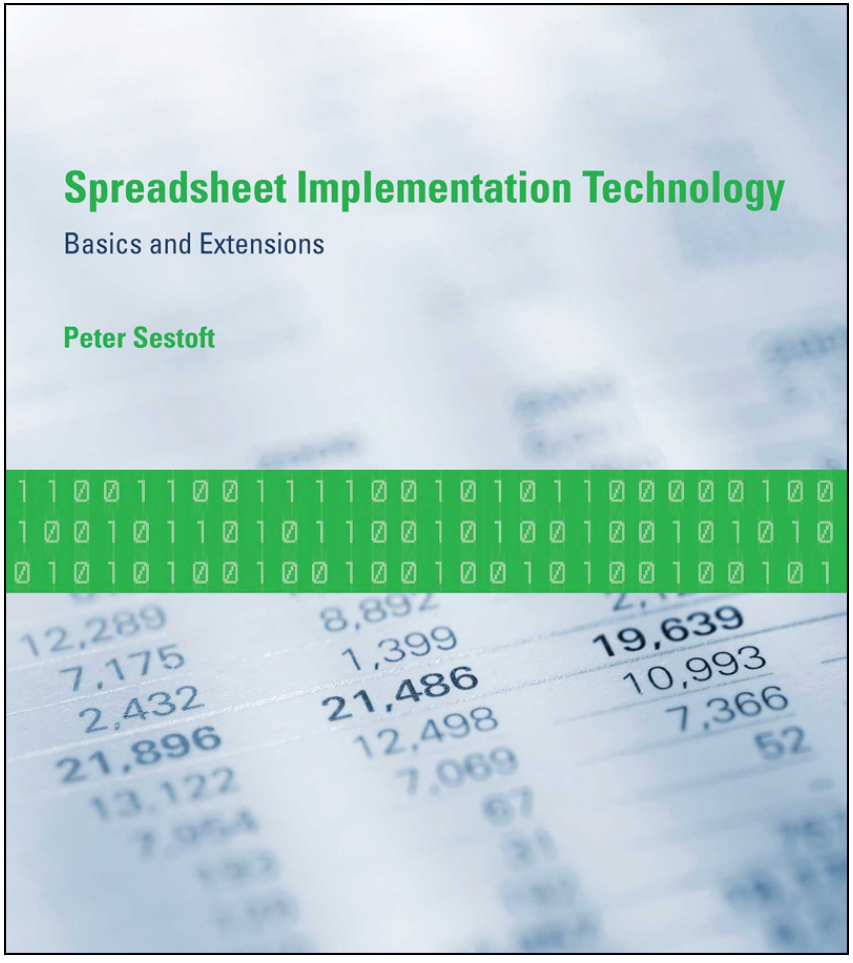

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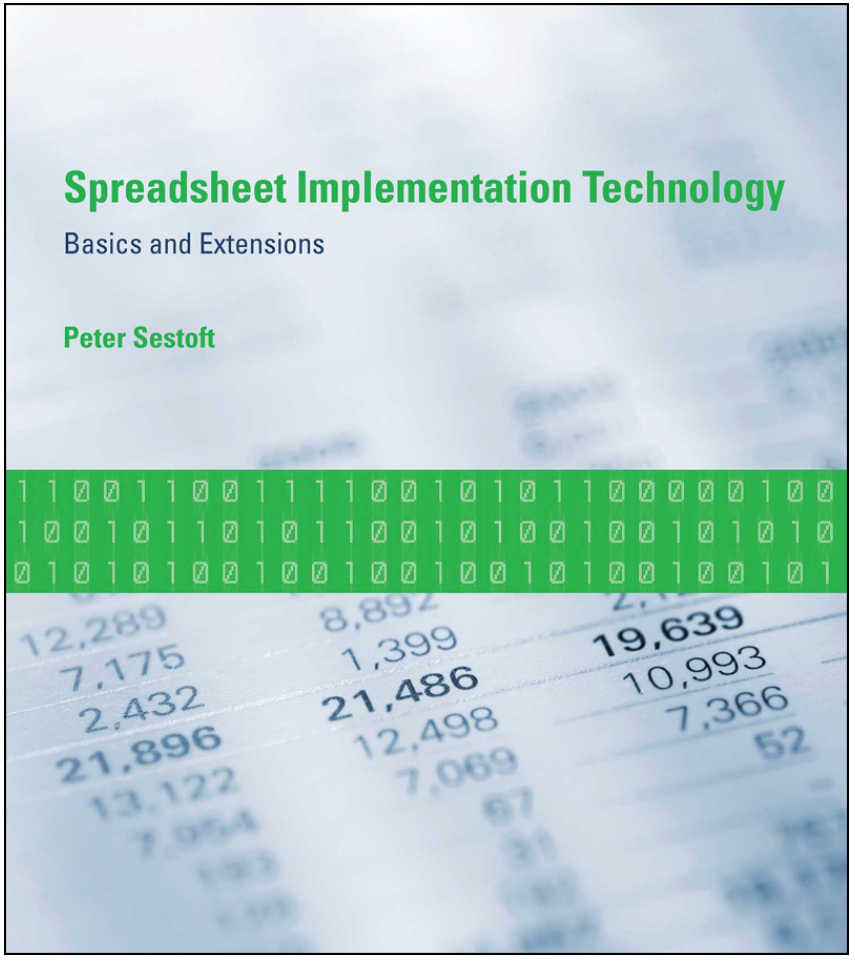

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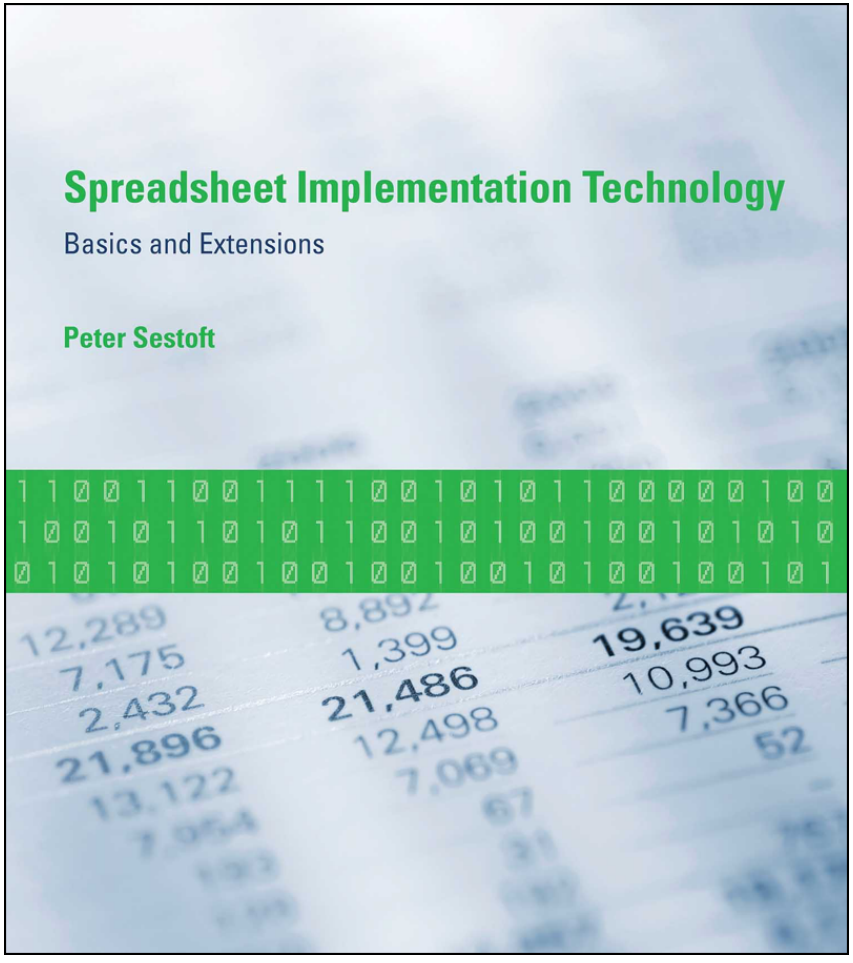

Thank You For Your Attention!

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Questions?

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