

The Art Of The Metaobject Protocol

The Art Of The Metaobject Protocol The art of the metaobject protocol In the rapidly evolving landscape of programming languages and software design, the metaobject protocol (MOP) stands out as a powerful and flexible tool for extending and customizing language behavior. By providing a systematic way to manipulate the language's own meta-level structures, the art of the metaobject protocol enables developers to craft highly adaptable, expressive, and maintainable systems. Whether you're working with object-oriented languages, developing domain-specific languages, or implementing sophisticated frameworks, understanding the core principles and practices of MOP can significantly enhance your programming toolkit. --- Understanding the Metaobject Protocol What Is a Metaobject Protocol? A metaobject protocol is a set of conventions, interfaces, and mechanisms that allow programmers to modify or extend the behavior of the language's meta-level objects—such as classes, methods, or object instances. Essentially, it provides a programmatic way to access and manipulate the language's own structure and semantics at runtime or compile-time. Key aspects include: Metaobjects: Objects that describe or control other objects, such as classes or1. methods. Protocol: The set of rules and operations that define how metaobjects can be2. accessed or modified. Reflection: The ability of a program to observe and modify its own structure and3. behavior. By exposing these internal mechanisms, MOPs enable developers to implement custom behaviors, enforce constraints, or introduce entirely new language features. Historical Context and Significance The concept of metaobject protocols gained prominence with the development of languages like Common Lisp, especially through the Common Lisp Object System (CLOS). CLOS's MOP allowed programmers to redefine class creation, method combination, and inheritance, offering a level of flexibility previously unavailable. This paradigm has since influenced various programming languages and frameworks, inspiring: Meta-programming techniques in Python, Ruby, and JavaScript 2 Domain-specific language development Frameworks that require runtime customization of object behaviors The art of the metaobject protocol lies in balancing flexibility with safety—empowering developers to innovate without compromising system stability. --- Core Principles of the Metaobject Protocol Reflection and Introspection At the heart of MOPs are reflection and introspection capabilities, which allow programs to: Examine their own structure and properties1. Modify class hierarchies, method dispatch, or object attributes dynamically2. This empowers dynamic behaviors, such as: Adding methods at runtime Changing inheritance relationships on the fly Implementing custom method resolution strategies Extensibility and Customization A well-designed MOP provides: Hooks and override points for language constructs1. Mechanisms to redefine core behaviors2. Tools for domain-specific extensions3. This allows developers to tailor the language environment to specific problem domains or application requirements. Separation of Concerns By isolating meta-level behavior from object-level logic, MOPs promote: Clearer code organization More maintainable systems Reduced complexity in core language implementations This separation ensures that customizations do not interfere with the fundamental semantics of the application. --- 3

Implementing the Art of the Metaobject Protocol Designing a Metaobject Protocol Creating an effective MOP involves several key steps: Identify the language constructs you wish to extend or customize, such as class1. creation, method invocation, or object instantiation. Define metaobjects that represent these constructs, encapsulating their2. properties and behaviors. Establish protocols—the interfaces and operations—that allow interaction with3. these metaobjects. Expose hooks and override points for users to implement custom behaviors.4. Ensure safety and consistency by constraining modifications or providing5. rollback mechanisms.

Common Techniques and Patterns

Several patterns are prevalent in MOP design: Method Caching: To optimize performance when manipulating metaobjects. Proxy Pattern: To wrap metaobjects for additional control or logging. Hook Methods: To allow custom behavior at key points in class or method lifecycle. Decorator Pattern: To add functionality dynamically without altering existing code.

Example: Redefining Class Creation

Suppose you want to control how classes are created in your language. You might: Create a metaobject representing class definitions.1. Define a protocol method like create-class that takes class parameters.2. Allow extensions to intercept this process, e.g., to enforce naming conventions or3. attach metadata. This customization can be achieved by overriding the default class creation method within the MOP, ensuring consistent and domain-specific behaviors. ---

Benefits of Mastering the Art of the Metaobject Protocol

Enhanced Flexibility

Mastering MOPs allows developers to: 4 Implement domain-specific languages (DSLs) Customize object behavior without changing core language code Create adaptive systems that evolve at runtime

Improved Maintainability

By encapsulating language customizations within well-defined metaobjects, systems become: More modular Easier to understand and modify Less prone to bugs caused by invasive modifications

Increased Expressiveness

The art of MOP unlocks new expressive capabilities, enabling: Advanced method dispatch strategies Complex class hierarchies and behaviors Innovative framework features tailored to specific needs ---

Challenges and Best Practices

Common Challenges

While powerful, MOPs can introduce complexity: Performance Overhead: Reflection and dynamic modifications may slow down1. execution. Complexity Management: Overuse can make systems hard to reason about.2. Safety Risks: Improper modifications can lead to inconsistent states or security3. issues.

Best Practices for Effective MOP Usage

To harness MOPs effectively: Use them judiciously; prefer explicit mechanisms when possible. Encapsulate meta-level logic to maintain clarity. Document protocols thoroughly for team consistency. Implement validation and safety checks for modifications. Leverage existing MOP frameworks or standards to avoid reinventing the wheel. 5 ---

Future Directions and Innovations in MOP

The field continues to evolve with innovations such as: Language-integrated meta-programming features Enhanced reflection APIs supporting safer and more expressive customizations Tools for visualizing and debugging metaobject interactions Standardization efforts to unify MOP approaches across languages

As software systems grow more complex, mastering the art of the metaobject protocol becomes increasingly valuable for developers seeking to push the boundaries of language design and system flexibility. ---

Conclusion

The art of the metaobject protocol is a vital skill for advanced software developers and language designers. By understanding and leveraging the principles of reflection, extensibility, and separation of concerns, programmers can craft systems that are not only powerful and flexible but also maintainable and future-proof. Whether customizing object behaviors, developing new language features, or building domain-specific tools, mastery of MOP empowers you to shape the language environment itself, opening

doors to innovative and efficient software solutions. **Question** What is the metaobject protocol (MOP) and why is it important in programming languages? The metaobject protocol (MOP) is a set of rules and interfaces that allow programmers to modify and extend the behavior of the language's object system at runtime. It provides a meta-level of abstraction for customizing class and object behaviors, enabling greater flexibility, adaptability, and metaprogramming capabilities. How does the art of the metaobject protocol enhance language extensibility? By exposing the internal mechanisms of object systems, the MOP allows developers to redefine or augment class creation, message dispatching, and inheritance models. This enables the creation of domain-specific languages, custom object models, and advanced metaprogramming constructs, significantly extending the language's native capabilities. What are some common use cases for implementing a metaobject protocol? Common use cases include creating custom class systems, implementing aspect-oriented programming, building domain-specific languages, adding debugging and logging hooks, and designing flexible serialization frameworks. MOPs are also used in research to explore new programming paradigms. **6** Which programming languages support or are known for their metaobject protocols? Languages like Common Lisp (via CLOS), Dylan, and Racket are well-known for their MOP capabilities. Additionally, languages such as Python and Ruby provide metaprogramming features that, while not formal MOPs, offer similar extensibility, with some frameworks explicitly implementing MOP-like interfaces. What are some challenges or pitfalls when designing and using a metaobject protocol? Challenges include increased complexity, potential for hard-to-maintain code, performance overhead, and difficulties in debugging. Overusing MOPs can lead to code that is difficult to understand and fragile, especially if internal language mechanisms are frequently altered. How does the art of the metaobject protocol relate to modern metaprogramming and reflection? MOPs are a form of advanced metaprogramming that provide structured hooks into the language's object system. They complement reflection and other metaprogramming techniques by offering more granular control over class and object behavior at runtime, enabling sophisticated language extensions. Can the principles of the metaobject protocol be applied to build custom frameworks or libraries? Absolutely. MOP principles allow developers to craft frameworks that can modify or extend core language features, leading to more adaptable libraries. For instance, ORM frameworks or serialization tools often leverage metaprogramming techniques inspired by MOP concepts. What is the future outlook for the art of the metaobject protocol in programming language development? As programming languages evolve towards greater flexibility and abstraction, the principles of MOP are likely to influence the design of future language features. Increased interest in domain-specific languages, runtime adaptability, and advanced metaprogramming suggests that MOP concepts will remain relevant and potentially become more integrated into language ecosystems. How can developers learn and experiment with the art of the metaobject protocol effectively? Developers can start by exploring languages with built-in MOP support, such as Common Lisp's CLOS, and studying their documentation and source code. Practical experimentation through building custom class systems or metaclasses, combined with reading research papers and tutorials on metaprogramming, can deepen understanding of MOP principles. The art of the metaobject protocol is a fascinating and sophisticated area within the realm of programming language design and implementation. It embodies the concept of making the structure and behavior of programming language objects and constructs accessible and modifiable at runtime. By enabling programmers to extend, customize, and

even redefine core language features dynamically, the metaobject protocol (MOP) opens up new horizons for flexibility, expressiveness, and powerful abstraction. This article explores the essence, principles, applications, and implications of the metaobject protocol, offering The Art Of The Metaobject Protocol 7 a comprehensive guide to understanding its artful intricacies. Understanding the Metaobject Protocol What is a Metaobject Protocol? At its core, a metaobject protocol is a set of conventions, interfaces, and mechanisms that allow programmers to interact with the language's own object system at a meta-level. While traditional object-oriented programming involves defining classes and objects that encapsulate data and behavior, a metaobject protocol provides a way to manipulate these classes, objects, and their behaviors dynamically. In more concrete terms, a MOP acts as a layer of abstraction above the language's core object system, exposing the internal mechanisms for defining, customizing, or extending language constructs such as classes, methods, or message dispatching. This enables developers to implement domain-specific languages, modify method invocation semantics, or enforce custom behaviors that are not originally built into the language. Historical Context and Significance The concept of a metaobject protocol was formalized in the late 1980s and early 1990s, notably through the work of Gregor Kiczales and colleagues on the Common Lisp Object System (CLOS). They recognized that the power and flexibility of object-oriented programming could be significantly enhanced if programmers could access and modify the object system itself. The result was the first formal MOP, which allowed for customizable method dispatch, class creation, and object behavior. The significance of MOPs lies in their ability to support reflection, metaprogramming, and domain-specific language (DSL) development, making programming languages more adaptable and expressive. By providing a programmable interface to the language's own semantics, MOPs enable a paradigm shift from static language features to dynamic, customizable systems. Core Principles of the Metaobject Protocol Reflection and Introspection Reflection is the ability of a program to examine and modify its own structure and behavior at runtime. MOPs heavily rely on reflection to allow meta-level manipulation of language constructs, such as classes, methods, or message-passing mechanisms. Features: - Querying class hierarchies - Inspecting method definitions - Altering class relationships dynamically Benefits: - Enables adaptive behaviors - Facilitates debugging and analysis - Supports the development of flexible frameworks The Art Of The Metaobject Protocol 8 Meta-Level Control Meta-level control refers to the capacity to define or override how language features behave, such as method dispatching, inheritance, or object creation. A MOP exposes these mechanisms as programmable entities, giving programmers fine-grained control. Features: - Custom method dispatch policies - Overriding class creation - Intercepting message passing Benefits: - Facilitates domain-specific behaviors - Allows implementation of alternative paradigms - Supports the creation of new language constructs Extensibility and Modifiability A defining characteristic of MOPs is their extensibility. They allow the programmer to modify language semantics without altering the core language implementation. Features: - Dynamic extension of classes and objects - Runtime modification of behavior - Embedding of new syntactic or semantic features Benefits: - Highly adaptable systems - Reusable and modular code - Customization aligned with domain needs Components and Architecture of a Metaobject Protocol Meta-Objects Meta-objects are objects that represent and control other objects or classes. Examples include class objects, method objects, or message dispatchers. They encapsulate the behavior and structure of language constructs. Features: - Store

class attributes - Manage method lookups - Control object creation

Meta-Methods Meta-methods are functions that operate on meta-objects, providing the means to customize behaviors like method invocation or class hierarchy management. Features: - Define how methods are selected and invoked - Extend or override default behaviors - Implement hooks for custom semantics

Protocols and Interfaces Protocols specify the set of rules and conventions through which meta-objects and meta-methods interact. They define how the language's core features can be extended or modified. Features: - Formal API for meta-level operations - Encapsulation of language semantics - Standards for interoperability

Applications and Use Cases of the Metaobject Protocol

The Art Of The Metaobject Protocol 9 Implementing Domain-Specific Languages (DSLs) MOPs are instrumental in building DSLs embedded within host languages. By customizing message passing or class creation, developers can tailor language syntax and semantics to specific problem domains. Example: - Creating a modeling language for financial contracts - Designing a declarative language for configuration management

Frameworks and Reflection-based Tools Many frameworks leverage MOPs to offer dynamic behaviors, such as object-relational mappers, GUI builders, or testing frameworks that introspect and modify object behaviors at runtime. Example: - Active Record pattern in ORM frameworks - Dynamic GUI component arrangements

Metaprogramming and Extensibility MOPs enable programmers to write code that writes or modifies code, allowing for flexible, reusable, and highly adaptable systems. Example: - Aspect-oriented programming - Code generation tools

Advanced Language Features and Paradigms Some languages incorporate MOPs to support advanced features like multiple inheritance, custom dispatch rules, or alternative object models. Example: - Multiple dispatch in Common Lisp - Customized inheritance models in languages like Dylan or Julia

Advantages of the Metaobject Protocol

- **High Flexibility:** Allows deep customization of language behavior.
- **Expressiveness:** Enables the creation of new abstractions and constructs.
- **Reusability:** Common patterns can be encapsulated in meta-objects, reducing boilerplate.
- **Reflection:** Facilitates debugging, analysis, and dynamic adaptation.
- **Domain-Specificity:** Supports tailoring the language to specific application needs.

Challenges and Limitations of the Metaobject Protocol

While MOPs offer powerful capabilities, they also come with certain challenges: - **Complexity:** Designing and understanding MOPs require deep knowledge of language internals. - **Performance Overhead:** Reflection and dynamic modifications can impact runtime efficiency. - **Maintenance Difficulties:** Code relying heavily on meta-level manipulations can be hard to debug and maintain. - **Portability:** Implementations of MOPs might not be portable across different language environments or versions. - **Learning Curve:** Developers need to familiarize themselves with meta-programming concepts

The Art Of The Metaobject Protocol 10 the specific MOP API.

Features to Consider When Choosing or Designing a MOP

When working with or designing a metaobject protocol, consider: - **Granularity:** Level of control provided over language constructs. - **Usability:** Ease of access, documentation, and clarity of the API. - **Performance:** Impact on runtime efficiency. - **Versatility:** Ability to handle various extension scenarios. - **Compatibility:** Integration with existing language features and tools.

Future Trends and Developments in the Art of the Metaobject Protocol

As programming languages evolve, the art of the metaobject protocol continues to advance: - **Language-Integrated Meta-Programming:** Seamless integration of meta-level features into language syntax. - **Automated MOP Generation:** Tools that generate MOPs based on high-level specifications. - **Hybrid Models:** Combining MOPs with other metaprogramming techniques like

macros or annotations. - Performance Optimization: Enhancing efficiency while maintaining flexibility. - Cross-Language Metaobject Protocols: Developing universal or language-agnostic meta-programming interfaces. Conclusion: The Art of Mastery in Metaobject Protocols The art of the metaobject protocol lies in balancing power, flexibility, and complexity. It demands a deep understanding of language internals, careful design, and a strategic approach to extending or customizing systems. When wielded skillfully, MOPs can transform programming languages into highly adaptable platforms capable of meeting diverse and evolving application needs. They embody a meta-level mastery—allowing programmers not just to use a language but to shape it according to their conceptual frameworks. While challenging, the mastery of MOPs opens up a realm of possibilities in software design, enabling the creation of innovative frameworks, languages, and tools that push the boundaries of conventional programming. As the landscape of computing continues to grow more complex and specialized, the art of the metaobject protocol will remain a vital skill for those seeking to craft flexible, extensible, and expressive software systems. metaobject protocol, reflective programming, runtime modification, object-oriented design, language extensibility, dynamic dispatch, meta-programming, runtime reflection, object model, language customization

The Art of the Metaobject Protocol ECOOP '91 European Conference on Object-Oriented Programming ECOOP 2002 - Object-Oriented Programming Advances in Object-Oriented Metalevel Architectures and Reflection Object-Oriented Technology: ECOOP '97 Workshop Reader Metalevel Architectures and Separation of Crosscutting Concerns Meta-Level Architectures and Reflection Pattern-Oriented Software Architecture, A System of Patterns Unconventional Programming Paradigms ECOOP '93 - Object-Oriented Programming Formal Methods for Components and Objects Variational Object-Oriented Programming Beyond Classes and Inheritance Reflection and Software Engineering Distributed Applications and Interoperable Systems ECOOP '95 - Object-Oriented Programming Object-Based Concurrent Computing Parallel and Distributed Processing ECOOP '97 - Object-Oriented Programming Fluent Python Intelligent Systems and Interfaces Gregor Kiczales Pierre America Boris Magnusson Christoph Zimmermann Jan Bosch Akinori Yonezawa Pierre Cointe Frank Buschmann Jean-Pierre Banâtre Oscar M. Nierstrasz Frank S. de Boer Mira Mezini Walter Cazzola Frank Eliassen Walter Olthoff Mario Tokoro José D. P. Rolim Mehmed Aksit Luciano Ramalho Horia-Nicolai Teodorescu

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the authors introduce this new approach to programming language design describe its evolution and design principles and present a formal specification of a metaobject protocol for clos the clos metaobject protocol is an elegant high performance extension to the commonlisp object system the authors who developed the metaobject protocol and who were among the group that developed clos introduce this new approach to programming language design describe its evolution and design principles and present a formal specification of a metaobject protocol for clos kiczales des rivières and bobrow show that the art of metaobject protocol design lies in creating a synthetic combination of object oriented and reflective techniques that can be applied under existing software engineering considerations to yield a new approach to programming language design that meets a broad set of design criteria one of the major benefits of including the metaobject protocol in programming languages is that it allows users to adjust the language to better suit their needs metaobject protocols also disprove the adage that adding more flexibility to a programming language reduces its performance in presenting the principles of metaobject protocols the authors work with actual code for a simplified implementation of clos and its metaobject protocol providing an opportunity for the reader to gain hands on experience with the design process they also include a number of exercises that address important concerns and open issues gregor kiczales and jim des rivières are members of the research staff and daniel bobrow is a research fellow in the system sciences laboratory at xerox palo alto research center

ecoop 91 is the fifth annual european conference on object oriented programming from their beginning the ecoop conferences have been very successful as a forum of high scientific quality where the newest developments connected to object oriented programming and related areas could be presented and discussed over the last few years object oriented technology has gained widespread use and considerable popularity in parallel with this the field has matured scientifically but there is still a lot of room for new ideas and for hot debates over fundamental issues as these proceedings show the 22 papers in this volume were selected by the programme committee from 129 submissions important issues discussed in the contributions are language design specification databases concurrency types and software development

this book constitutes the refereed proceedings of the 16th european conference on object oriented programming ecoop 2002 held in malaga spain in june 2002 the 24 revised full papers presented together with one full invited paper were carefully reviewed and selected from 96 submissions the book offers topical sections on aspect oriented software development java virtual machines distributed systems patterns and architectures languages optimization theory and formal techniques and miscellaneous

the importance of object oriented metalevel architectures metaobjects and reflection continues to grow in computer science this applies to traditional fields such as artificial intelligence and object oriented programming languages as well as to parallel processing and operating systems advances in

object oriented metalevel architectures and reflection presents some of the standard setting research in this field the book is structured with an introductory chapter that lays the necessary foundation for readers new to the field the next five parts discuss operating systems artificial intelligence languages concurrent objects and application support each part itself has a brief introduction that presents the basics for understanding the particular topic

this book constitutes the joint refereed post conference proceedings of 12 workshops held in conjunction with the 11th european conference on object oriented programming ecoop 97 in jyvskyl finland in june 1997 the volume presents close to 100 revised selected contributions including surveys by the respective workshop organizers the wealth of up to date information provided spans the whole spectrum of object technologies from theoretical and foundational issues to applications in a variety of domains

this volume constitutes the proceedings of reflection 2001 the third international conference on metalevel architectures and separation of crosscutting concerns which was held in kyoto september 25-28 2001 metalevel architectures and reflection have drawn the attention of researchers and practitioners throughout computer science reflective and metalevel techniques are being used to address real world problems in such areas as programming languages operating systems databases distributed computing expert systems and web computing separation of concerns has been a guiding principle of software engineering for nearly 30 years but its known benefits are seldom fully achieved in practice this is primarily because traditional mechanisms are not powerful enough to handle many kinds of concerns that occur in practice over the last 10 years to overcome the limitations of traditional frameworks many researchers including several from the reflection community have proposed new approaches for the first time papers on advanced approaches to separation of concerns were explicitly solicited following the success of previous conferences such as imsa 92 in tokyo reflection 96 in san francisco and reflection 99 in saint malo we hope that the conference provided an excellent forum for researchers with a broad range of interests in metalevel architectures reflective techniques and separation of concerns in general

this book constitutes the refereed proceedings of the second international conference on meta level architectures and reflection reflection 99 held in st malo france in july 1999 the 13 revised full papers presented were carefully selected from 44 submissions also included are six short papers and the abstracts of three invited talks the papers are organized in sections on programming languages meta object protocols middleware multi media work in progress applications and meta programming the volume covers all current issues arising in the design and analysis of reflective systems and demonstrates their practical applications

pattern oriented software architecture is a new approach to software development this book represents the progression and evolution of the pattern approach into a system of patterns capable of describing and documenting large scale applications a pattern system provides on one level a pool of proven solutions to many recurring design problems on another it shows how to combine individual patterns into heterogeneous structures and as such it can be used to facilitate a

constructive development of software systems uniquely the patterns that are presented in this book span several levels of abstraction from high level architectural patterns and medium level design patterns to low level idioms the intention of and motivation for this book is to support both novices and experts in software development novices will gain from the experience inherent in pattern descriptions and experts will hopefully make use of add to extend and modify patterns to tailor them to their own needs none of the pattern descriptions are cast in stone and just as they are borne from experience it is expected that further use will feed in and refine individual patterns and produce an evolving system of patterns visit our page wiley.com/compbooks

unconventional approaches to programming have long been developed in various niches and out of curiosity and they constitute a reservoir of alternative avenues to deal with unknown programming challenges new paradigms of programming are currently experiencing a renewed period of interest and growth to cope with problems from specific application domains this book constitutes the thoroughly refereed post proceedings of the international workshop on unconventional programming paradigms upp 2004 held at le mont saint michel france in september 2004 the 26 revised full papers presented together with an invited paper on quantum computing were carefully reviewed for presentation in the book the papers are organized in topical sections on chemical computing amorphous computing bio inspired computing autonomic computing and generative programming

it is now more than twenty five years since object oriented programming was invented actually more than thirty years since work on simulation started but by all accounts it would appear as if object oriented technology has only been discovered in the past ten years when the first european conference on object oriented programming was held in paris in 1987 i think it was generally assumed that object oriented programming like structured programming would quickly enter the vernacular and that a conference on the subject would rapidly become superfluous on the contrary the range and impact of object oriented approaches and methods continues to expand and spite the inevitable oversell and hype object oriented technology has reached a level of scientific maturity that few could have foreseen ten years ago object oriented technology also cuts across scientific cultural boundaries like perhaps no other field of computer science as object oriented concepts can be applied to virtually all the other areas and affect virtually all aspects of the software life cycle so in retrospect emphasizing just programming in the name of the conference was perhaps somewhat short sighted but at least the acronym is pronounceable and easy to remember this year's ecoop attracted 146 submissions from around the world making the selection process even tougher than usual the selected papers range in topic from programming language and database issues to analysis and design and reuse and from experience reports to theoretical contributions

this book presents 12 revised lectures given by top researchers at the 5th international symposium on formal methods for components and objects fmco 2006 held in amsterdam netherlands in november 2006 it provides a unique combination of ideas on software engineering and formal methods that reflect the current interest in the application or development of formal methods for large scale software systems such as component based systems and object systems

purpose of the book this book presents an approach to improve the standard object oriented programming model the proposal is aimed at supporting a larger range of incremental behavior variations and thus promises to be more effective in mastering the complexity of today's software the ability of dealing with the evolutionary nature of software is one of main merits of object oriented data abstraction and inheritance object orientation allows to organize software in a structured way by separating the description of different kinds of an abstract data type into different classes and loosely connecting them by the inheritance hierarchy due to this separation the software becomes free of conditional logics previously needed for distinguishing between different kinds of abstractions and can thus more easily be incrementally extended to support new kinds of abstractions in other words classes and inheritance are means to properly model variations of behavior related to the existence of different kinds of an abstract data type the support for extensibility and reuse with respect to such kind specific behavior variations is among the main reasons for the increasing popularity of object oriented programming in the last two decades however this popularity does not prevent us from questioning the real effectiveness of current object oriented techniques in supporting incremental variations in fact this popularity makes a critical investigation of the variations that can actually be performed incrementally even more important

this book presents the state of the art of research and development of computational reflection in the context of software engineering reflection has attracted considerable attention recently in software engineering particularly from object oriented researchers and professionals the properties of transparency separation of concerns and extensibility supported by reflection have largely been accepted as useful in software development and design reflective features have been included in successful software development technologies such as the java language the book offers revised versions of papers presented first at a workshop held during oopsla 99 together with especially solicited contributions the papers are organized in topical sections on reflective and software engineering foundations reflective software adaptability and evolution reflective middleware engineering java based reflective languages and dynamic reconfiguration through reflection

this book constitutes the refereed proceedings of the 6th ifip wg 6.1 international conference on distributed applications and interoperable systems dais 2006 held in bologna italy june 2006 the book presents 21 revised regular and 5 revised work in progress papers on architectures models technologies and platforms for interoperable scalable and adaptable systems and cover subjects as methodological aspects tools and language of building adaptable distributed and interoperable services and many more

for the ninth time now the european conference on object oriented programming provides a mid summer gathering place for researchers practitioners students and newcomers in the field of object technology despite fierce competition from an increasing number of attractive conferences on object related topics ecoop has successfully positioned itself as the premier european object technology conference one reason is without doubt the composition of the conference week and the nature of its events running in parallel on the first two days a comprehensive tutorial program and a very selective workshop program are offered to attendees this is followed by a three day technical program organized

in a single track providing a highly communicative atmosphere of scientific exchange and learning overlapping with these events are a two day industrial exhibition and a two day opportunity for non industrial system dev ops to demonstrate their software thus ecoop is not just a conference on programming but an event touching on the full spectrum of object technology this volume constitutes the proceedings of the ninth european conference on object oriented programming ecoop held in aarhus denmark august 7 11 1995 previous ecoop conferences were held in paris france oslo norway nottingham england ottawa canada jointly with oopsla geneva switzerland utrecht the netherlands kaiserslautern germany and bologna italy object technology continues to increase its impact on the corporate world

the ecoop 91 workshop on object based concurrent computing was organized to provide a forum on concurrent distributed and open ended computing the emphasis was on conceptual theoretical and formal aspects as well as practical aspects and sound experience since such a viewpoint was deemed indispensable to investigate and establish a basis for future development this volume contains 12 papers selected from 25 presented at the workshop together with a paper by j a goguen who was an invited speaker at the workshop the papers are classified into four categories formal methods 1 three papers are concerned with the formal semantics of concurrent objects based on process calculi formal methods 2 four papers are concerned with various formal approaches to the semantics of concurrent programs concurrent programming three papers models three papers are concerned with models for concurrent systems

this book constitutes the refereed proceedings of 11 ipps spdp 98 workshops held in conjunction with the 13th international parallel processing symposium and the 10th symposium on parallel and distributed processing in san juan puerto rico usa in april 1999 the 126 revised papers presented were carefully selected from a wealth of papers submitted the papers are organised in topical sections on biologically inspired solutions to parallel processing problems high level parallel programming models and supportive environments biologically inspired solutions to parallel processing parallel and distributed real time systems run time systems for parallel programming reconfigurable architectures java for parallel and distributed computing optics and computer science solving irregularly structured problems in parallel personal computer based workstation networks formal methods for parallel programming embedded hpc systems and applications

when do the lebesgue bochner function spaces contain a copy or a complemented copy of any of the classical sequence spaces this problem and the analogous one for vector valued continuous function spaces have attracted quite a lot of research activity in the last twenty five years the aim of this monograph is to give a detailed exposition of the answers to these questions providing a unified and self contained treatment it presents a great number of results methods and techniques which are useful for any researcher in banach spaces and in general in functional analysis this book is written at a graduate student level assuming the basics in banach space theory

python's simplicity lets you become productive quickly but this often means you aren't using everything it has to offer with this hands on guide you'll learn how to write effective idiomatic python

code by leveraging its best and possibly most neglected features author luciano ramalho takes you through python s core language features and libraries and shows you how to make your code shorter faster and more readable at the same time many experienced programmers try to bend python to fit patterns they learned from other languages and never discover python features outside of their experience with this book those python programmers will thoroughly learn how to become proficient in python 3 this book covers python data model understand how special methods are the key to the consistent behavior of objects data structures take full advantage of built in types and understand the text vs bytes duality in the unicode age functions as objects view python functions as first class objects and understand how this affects popular design patterns object oriented idioms build classes by learning about references mutability interfaces operator overloading and multiple inheritance control flow leverage context managers generators coroutines and concurrency with the concurrent futures and asyncio packages metaprogramming understand how properties attribute descriptors class decorators and metaclasses work

the field of intelligent interfaces and systems has seen a fast growth last decade an impressive number of papers conference tutorials and volumes were devoted to the topic ten years ago intelligent systems constituted a rather exotic topic and many were skeptic that such systems amount to more than a nice name nowadays intelligent systems represent a powerful tool in many applications in all industrial fields their development evolved on both the horizontal dimension with a constantly increasing number of applications and on the vertical dimension by including more capabilities going from sensoric to neurofuzzy systems intelligent agents speech and image understanding and decision making in complex environments the domain constituted by the intelligent systems is now too large to be covered in a single volume consequently the editors considered a balance between several selected sub fields to insure the unity of the volume yet allowing a large enough horizon and a consistent understanding of the entire field including real life applications the volume represents a comprehensive coverage of the field including fundamental aspects software sensors and hardware related issues moreover the contributors to this volume offer beyond a systematic overview of intelligent interfaces and systems deep practical knowledge in building and using intelligent systems in various applications a special emphasis is on specific aspects and requirements in applications in addition the second editor proposes two chapters addressing the management of projects dealing with intelligent systems

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