Managing Complexity of Enterprise Information Systems

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Keynote Presentation

Leszek A. Maciaszek

Macquarie University, Sydney, Australia
www.comp.mq.edu.au/~leszek

Main points

- *Measurably-supportable systems*
- *Supportable system → dependency metrics*
- *Architecture (hierarchy) that minimizes (potential) dependencies*
- *Dependencies on classes, messages, events, inheritance*
- *Proactive approach (architecture → implementation) and reactive approach (implementation → architecture)*
- *Two aims of reactive approach:*
  - *Conformance to the architecture*
  - *Comparison of different implementations*
- *Global supportability metrics (fuzzy logic?)*
- *The issue of project management and availability of managerial tools*

References

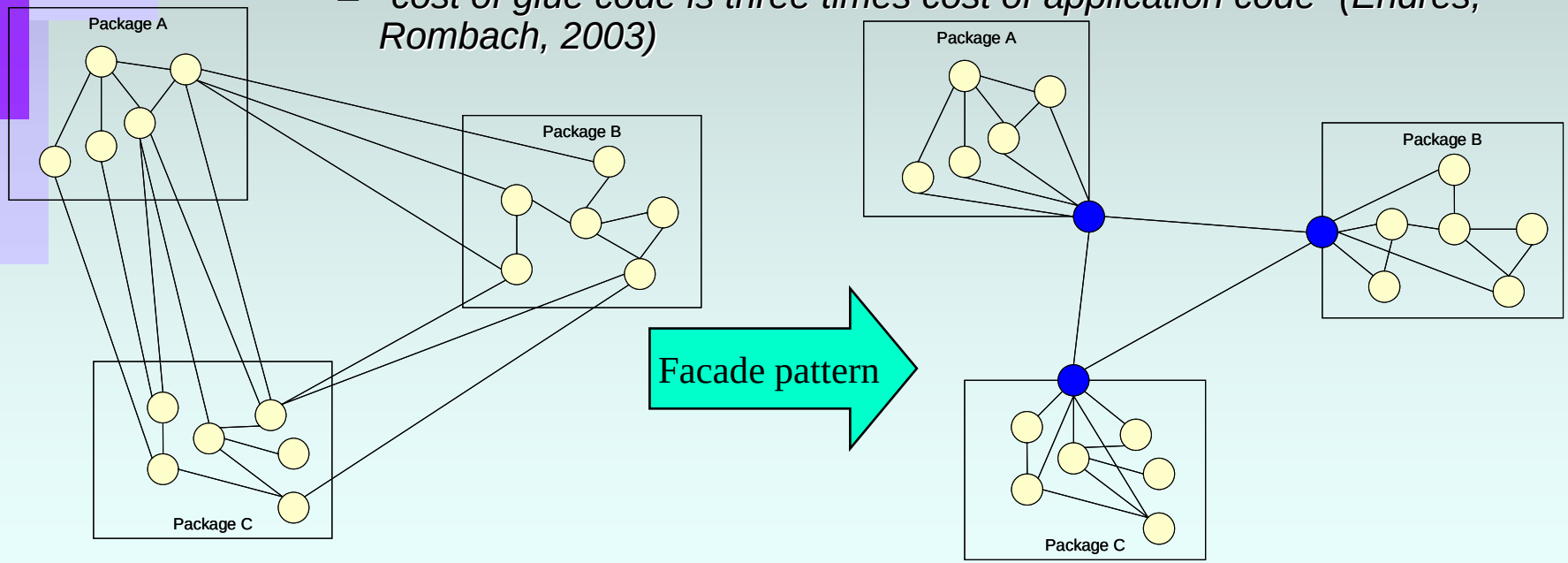
- Maciaszek, L.A. (2001): *Requirements Analysis and System Design. Developing Information Systems with UML*, Addison-Wesley, 378p. {translated to Chinese, Russian and Italian}
- Maciaszek, L.A. (2004): *Requirements Analysis and Systems Design*, 2nd ed., Addison-Wesley, ~630p. (to appear Sept 2004)
  - http://www.comp.mq.edu.au/books/rasd2ed/
- Maciaszek, L.A. and Liong, B.L. (2004): *Practical Software Engineering. A Case-Study Approach*, Addison-Wesley, 829p. (to appear May 2004)
  - http://www.comp.mq.edu.au/books/pse/

The trouble with a good many of us is that we come to a conclusion before we arrive at the end. (F.J. Mills)

- *Hierarchical structures reduce complexity (Herb Simon, 1962)*
  - *complex – made up of a large number of parts that interact in a non-simple way*
- *A structure is stable if cohesion is strong and coupling low (Larry Constantine, 1974)*
  - *cohesion – intra-module communication*
  - *coupling – inter-module interaction*
- *Only what is hidden can be changed without risk (David Parnas, 1972)*
- *Separation of concerns leads to standard architectures (Ernst Denert, 1991)*
- *An evolving system increases its complexity unless work is done to reduce it (Meir Lehman)*

Size and complexity

- *Legacy systems*
  - *Monolithic, processing sequential and predictable*
  - *Complexity = size*
- *Object systems*
  - *Distributed, processing random and unpredictable*
  - *Complexity in wires*
    - *"cost of glue code is three times cost of application code" (Endres, Rombach, 2003)*



Object systems → new legacy systems?

- *Unsupportable system → legacy system*
  - *software systems do not wear out; they only lose relevance*
- *Supportability = understandability + maintainability + scalability*
- *Properties of complex systems that are supportable:*
  - *Take the form of hierarchy and composition of objects*
  - *Intra-linkages of components stronger than inter-linkages*
  - *Dynamic links legalized as static associations*
  - *Complex systems that work are result of simple systems that worked (evolution)*
  - *“Evolution has a preference for hierarchical systems because they are more stable when interrupted” (Endres, Rombach, 2003)*

Difficulties that we are facing

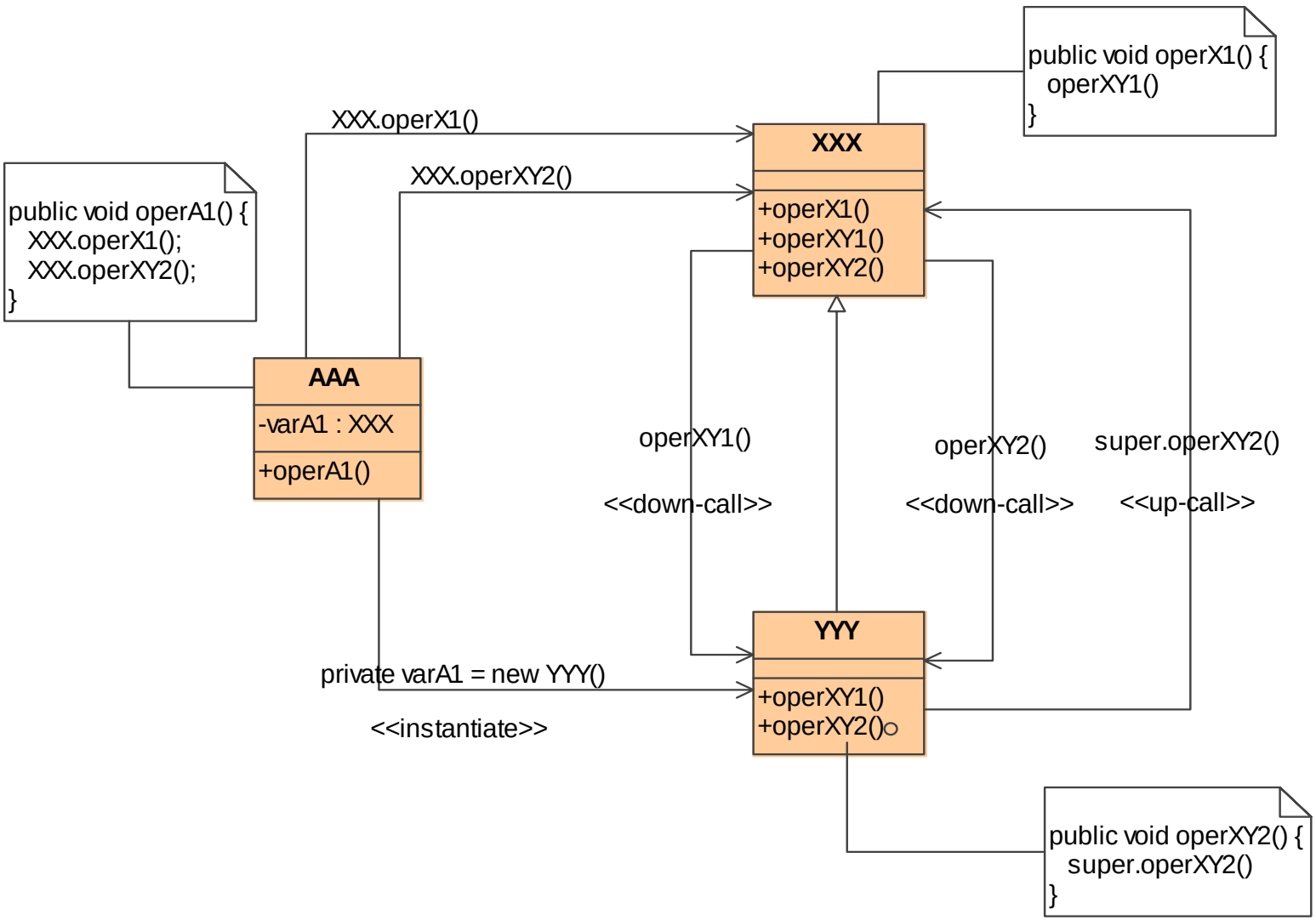
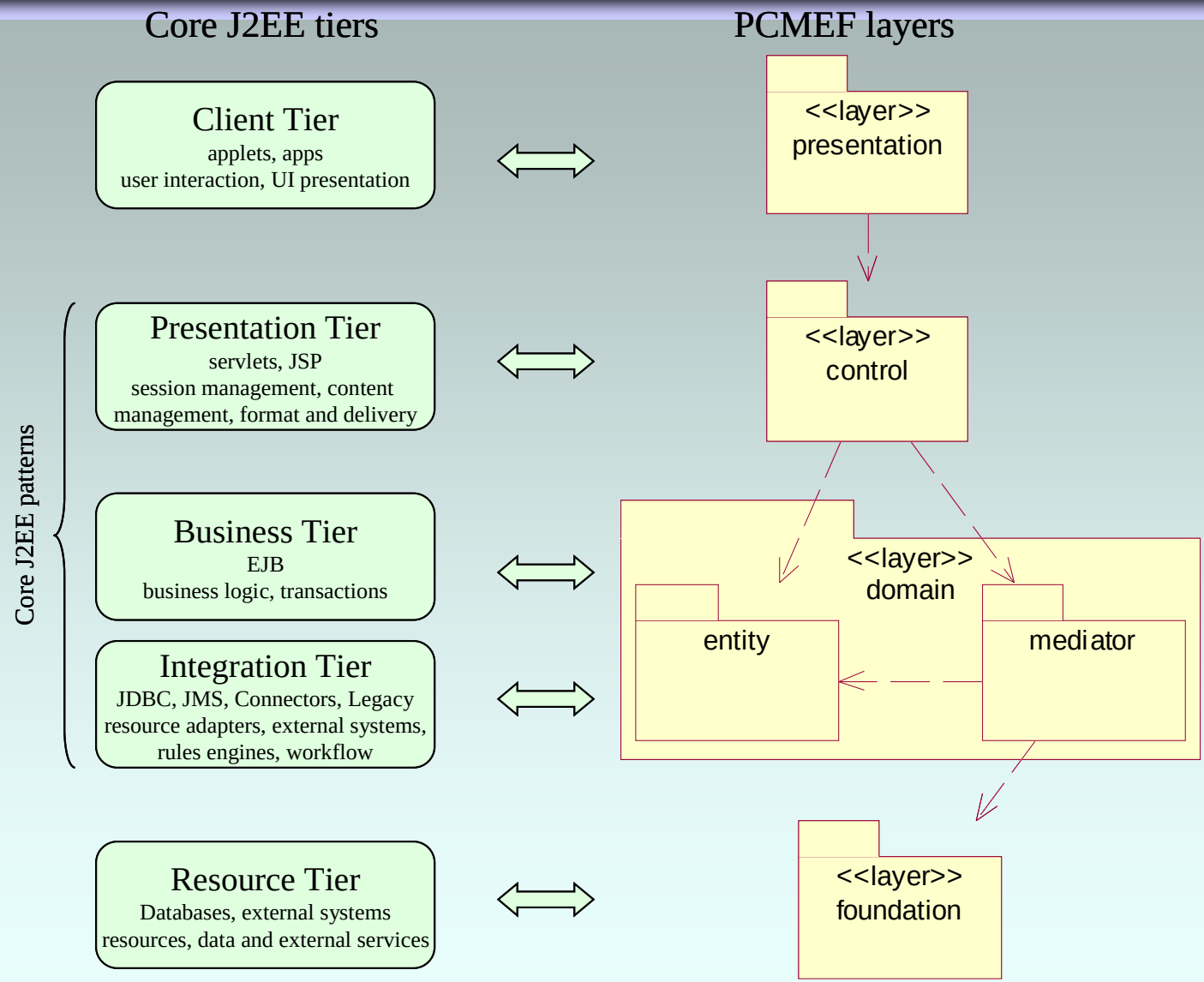


Figure 1. Program dependencies

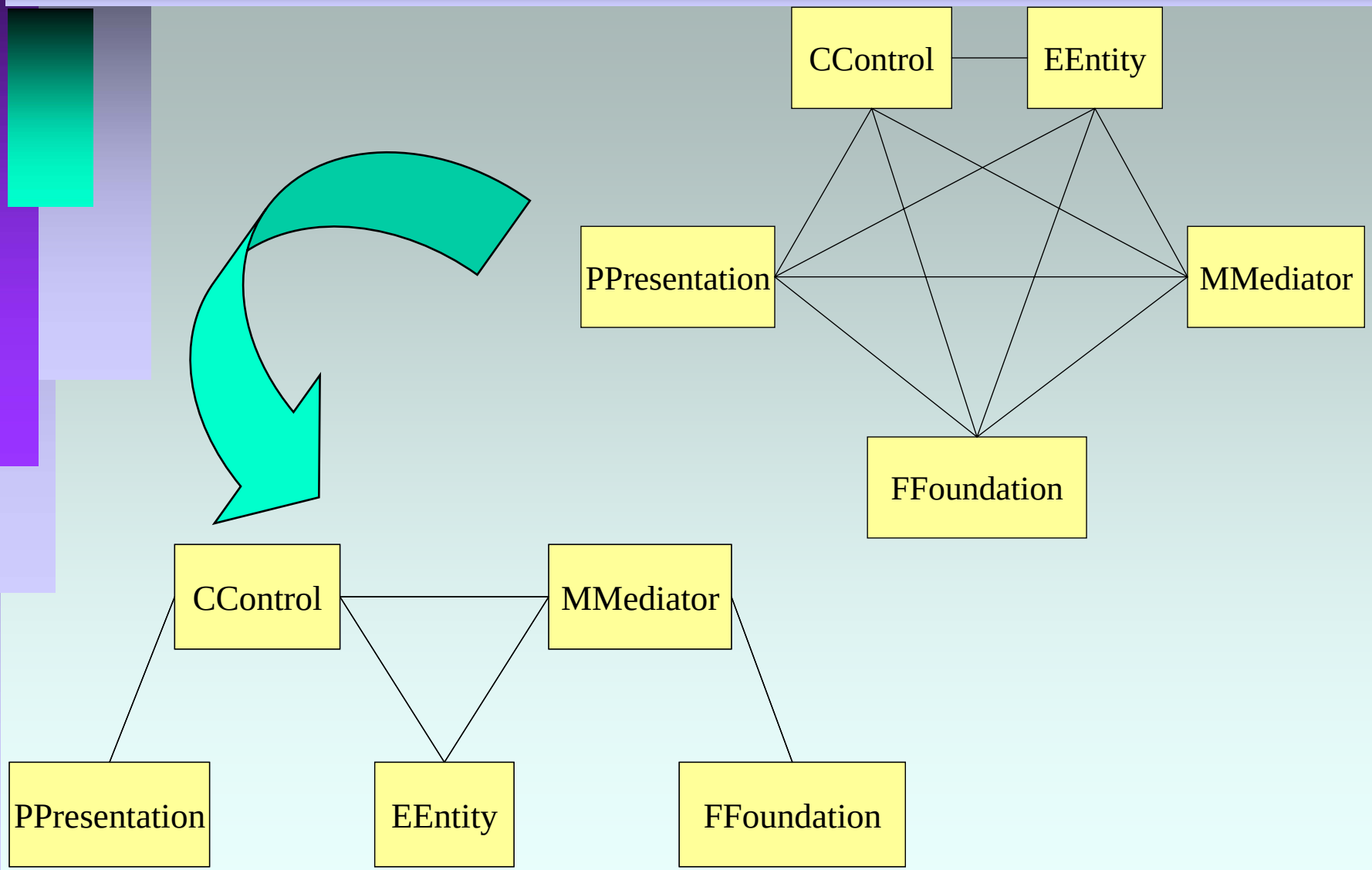
Application design objectives

- *a hierarchical **layering** of software modules that reduces complexity and enhances understandability of module dependencies by disallowing direct object intercommunication between non-neighboring layers, and*
- *an enforcement of programming standards that make module **dependencies** visible in compile-time program structures and that forbid muddy programming solutions utilizing just run-time program structures*

Architecture



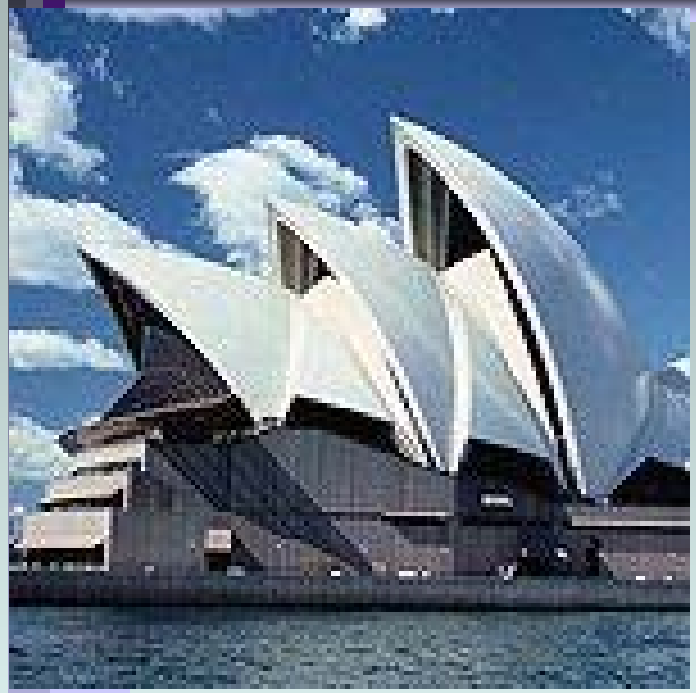
...converting to PCMEF design



PCMEF subsystems

- *The presentation subsystem*
  - *classes that handle the graphical user interface (GUI) and assist in human-computer interactions.*
- *The control subsystem*
  - *classes capable to understand what program logic is*
    - *searching for information in entity objects*
    - *asking the mediator layer to bring entity objects to memory from the database.*
- *The entity subsystem*
  - *manages business objects currently in memory*
  - *container classes*
  - *containers are linked*
- *The mediator subsystem*
  - *mediates between entity and foundation subsystems to ensure that control gets access to business objects*
  - *manages the memory cache and synchronizes the states of business objects between memory and the database*
- *The foundation subsystem*
  - *classes that know how to talk to the database*
  - *produces SQL to read and modify the database*

PCMEF patterns

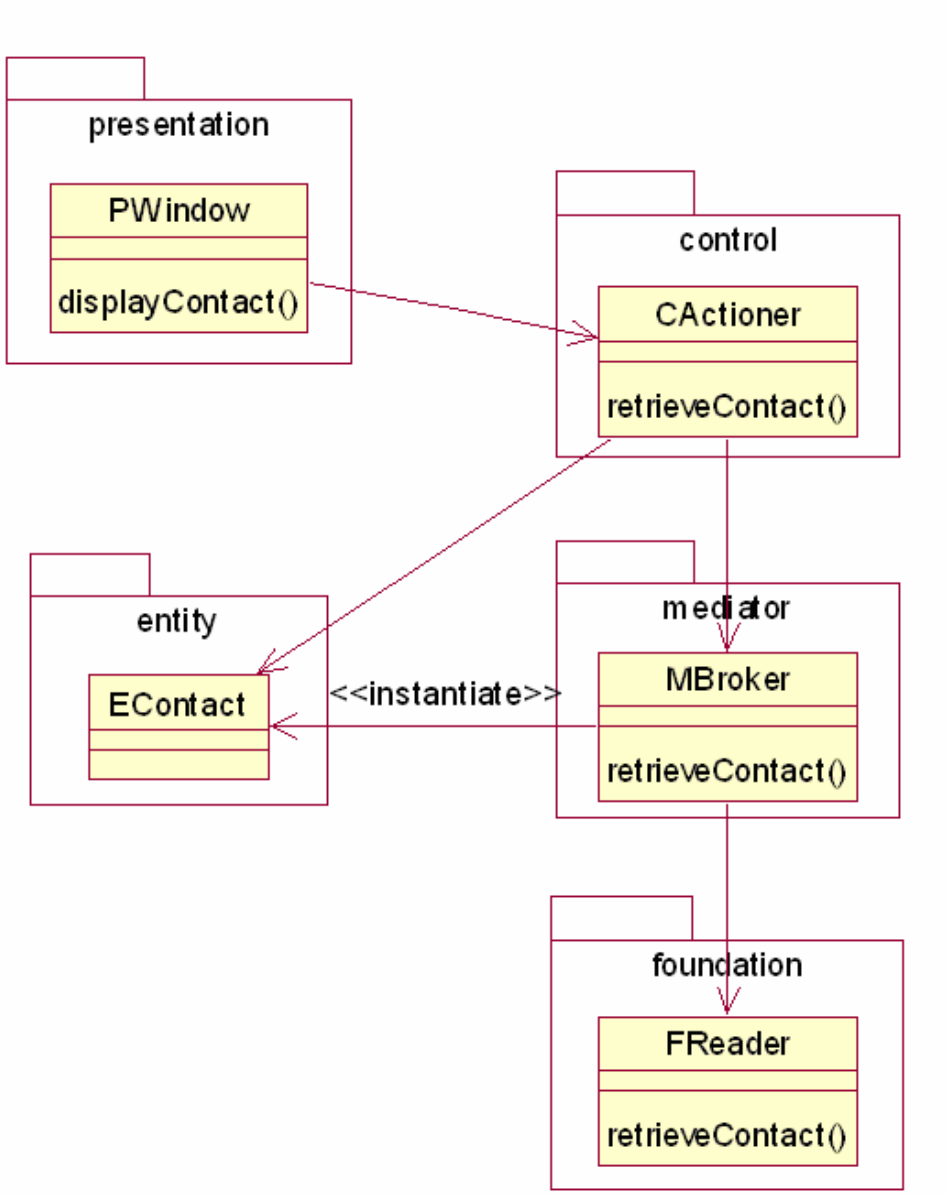


- *PCMEF architecture is based on some well-known design patterns and on few new patterns specific to PCMEF*
- *Main source of patterns for PCMEF are*
  - *GoF (Gang of Four – [GAMM1995]),*
  - *PEAA (Patterns of Enterprise Application Architecture – [FOWL2003])*
  - *Core J2EE [ALUR2003]*
- *Patterns particularly useful include: MVC, Façade, Abstract Factory, Chain of Responsibility, Observer, Mediator, Identity Map, Data Mapper, Lazy Load, OID Proxy.*

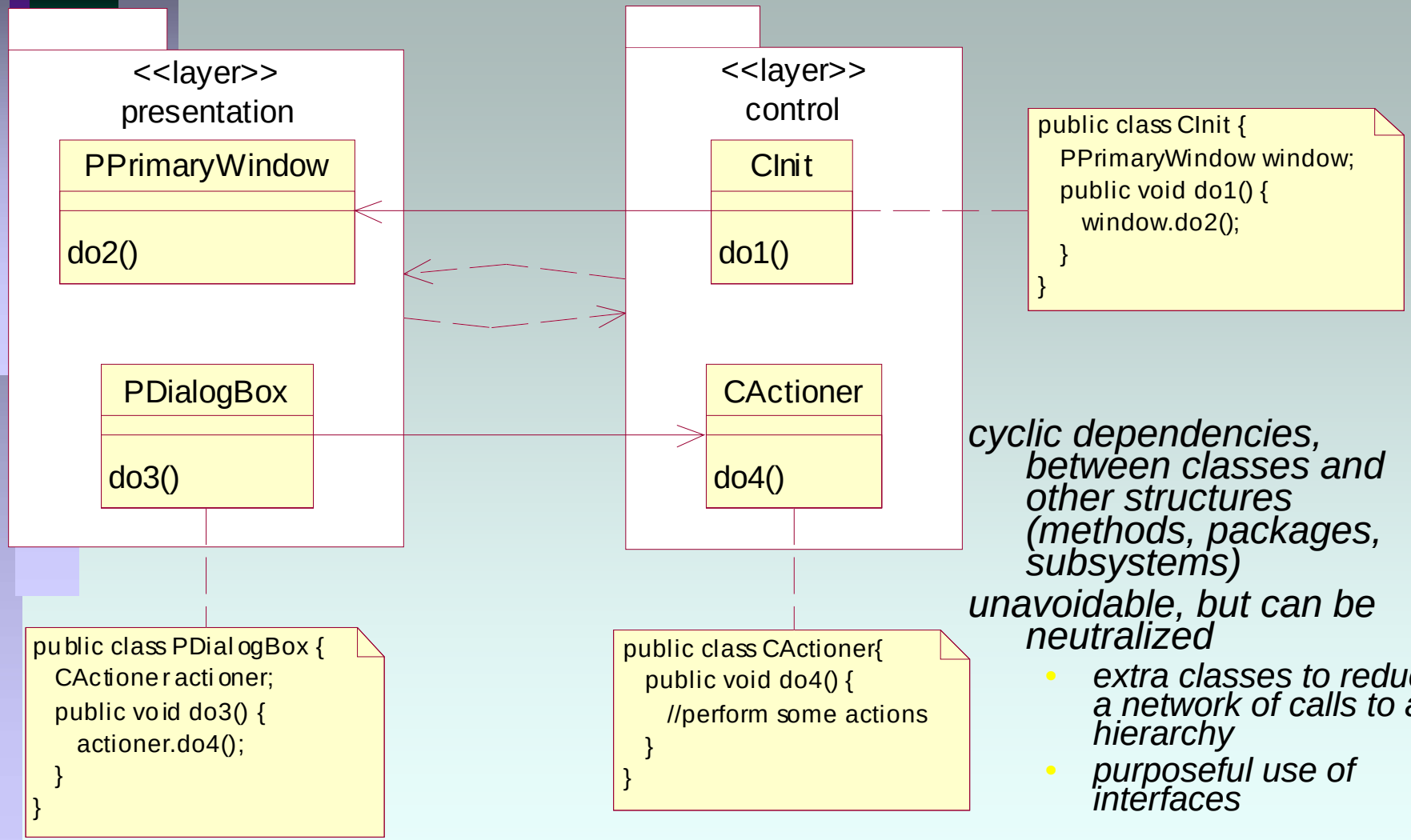
CNP, NCP, EAP, DDP

- *CNP – class naming*
  - *name of each class and each interface in the system should identify the subsystem/package layer to which it belongs*
  - *ensuring that each class begins with a single letter identifying the PCMEF layer (i.e. P, C, etc.)*
    - *EVideo means that the class is in the entity subsystem*
    - *IMVideo means that the interface is in the mediator subsystem*
- *NCP – neighbor communication*
  - *objects can communicate across layers only by using direct neighbors*
  - *chains of message passing*
- *EAP – explicit association*
  - *legitimizes run-time object communication in compile-time data structures.*
- *DDP – downward dependency*
  - *higher PCMEF layers depend on lower layers*
  - *lower layers should be designed to be more stable*

Chain of responsibility pattern



CEP – cycle elimination

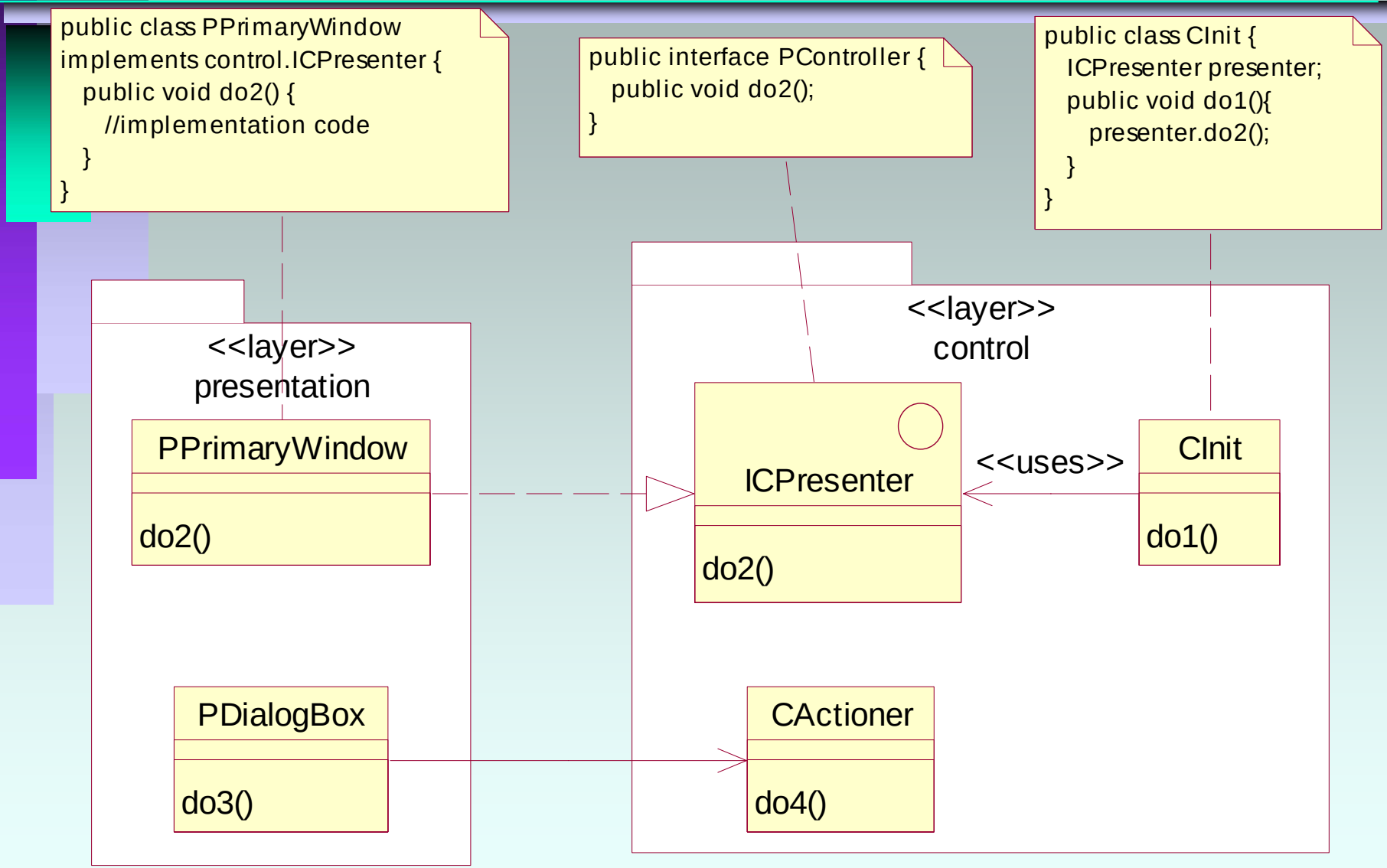


cyclic dependencies, between classes and other structures (methods, packages, subsystems)

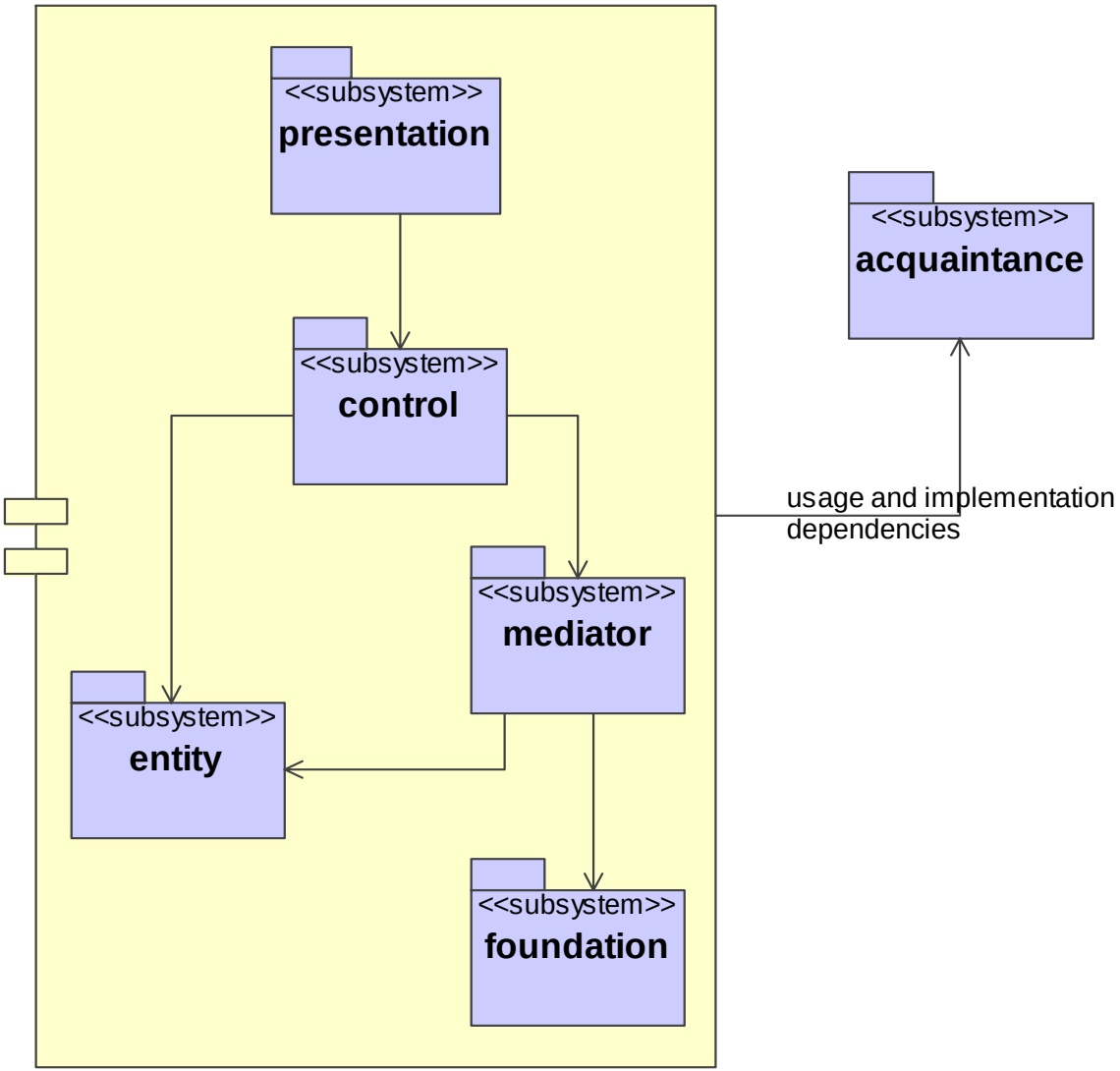
unavoidable, but can be neutralized

- *extra classes to reduce a network of calls to a hierarchy*
- *purposeful use of interfaces*

CEP


public class PPrimaryWindow
implements control.ICPresenter {
public void do2() {
//implementation code
}
}
public interface PController {
public void do2();
}
public class CInit {
ICPresenter presenter;
public void do1(){
presenter.do2();
}
}
<<layer>>
presentation
PPrimaryWindow
do2()
PDialogBox
do3()
<<layer>>
control
ICPresenter
do2()
<<uses>>
CInit
do1()
CActioner
do4()

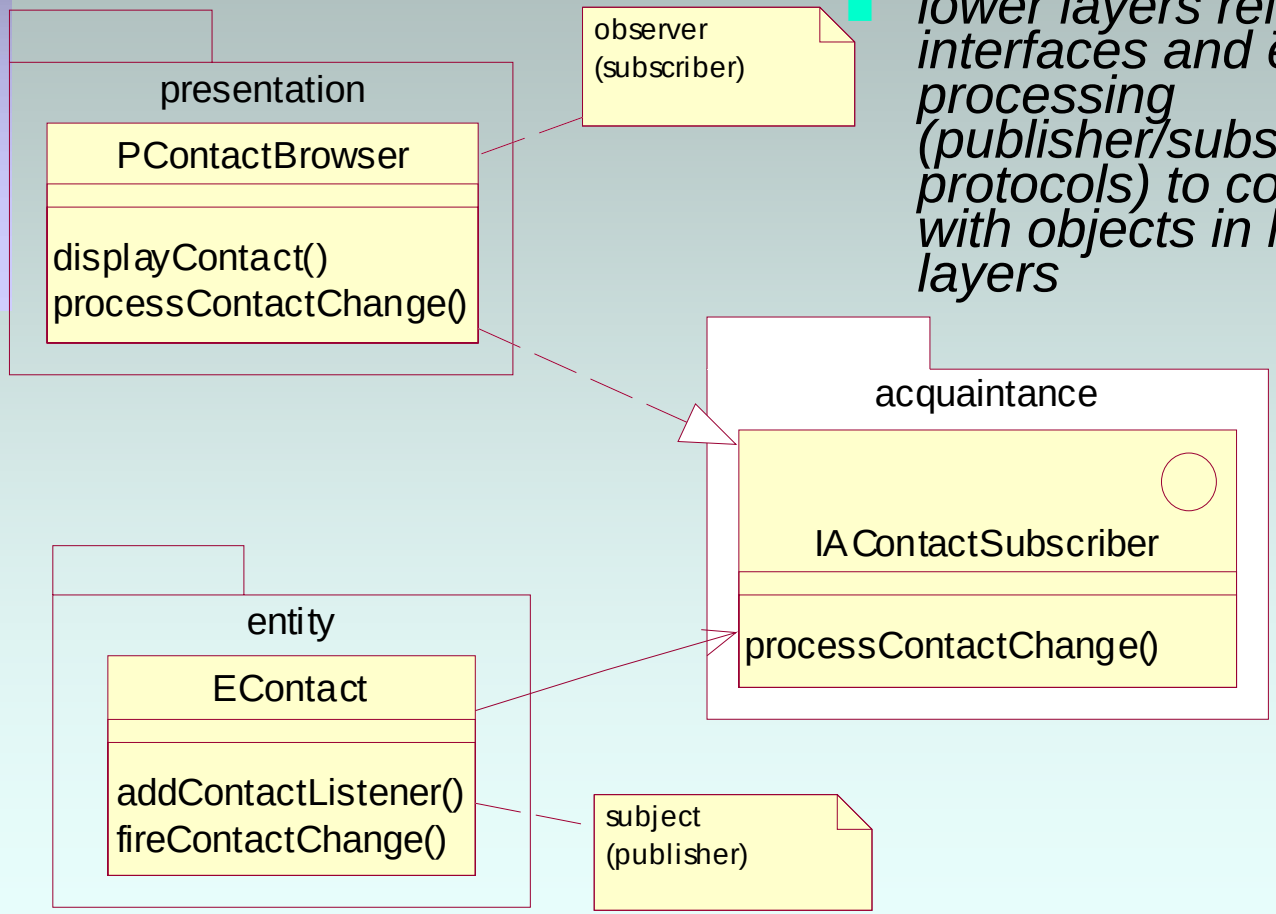
APP – acquaintance package



- *separate layer of interfaces to support more complex object communication under strict supportability guidelines*
- *subsystem of interfaces only*
  - *other objects in the system can use these interfaces, and pass them in arguments to method calls, instead of concrete objects → classes in non-neighboring subsystems can communicate without knowing the concrete suppliers of services (and, therefore, without creating dependencies on concrete classes).*

UNP – upward notification

- *upward communication that minimizes object dependencies*
- *lower layers rely on interfaces and event processing (publisher/subscriber protocols) to communicate with objects in higher layers*



PCMEF conformance verification

- *Architectural design takes a **proactive approach** to managing dependencies in software.*
  - *This is a forward-engineering approach – from design to implementation.*
  - *The aim is to deliver a software design that minimizes dependencies by imposing an architectural solution on programmers.*
- *Proactive approach must be supported by the reactive approach that aims at measuring dependencies in implemented software.*
  - *This is a reverse-engineering approach – from implementation to design.*
  - *The implementation may or may not conform to the desired architectural design.*
  - *The purpose is to show in numbers how much the implemented system is worse than a PCMEF solution (or other dependency-minimizing architecture)*

CCD

DEFINITION: **Cumulative Class Dependency (CCD)** is the total supportability cost over all classes $C_{i\{i=1,\ldots,n)}$ in a system of the number of classes $C_{j(j<=1,\ldots,n)}$ to be potentially changed in order to modify each class C_i.

- *Calculation of CCD assumes adherence to the architectural framework.*
- *If the framework is found to be broken, the CCD is calculated as if a class can depend on any other class in the system.*
  - *probability theory method - the combinations counting rule*
  - *The CCD is the number of different combinations of pairs of dependent classes which can be formed from the total number of classes in the design multiplied by 2 (cycles)*

$$ {}_{n}CCD_2 = \frac{n!}{2!(n-2)!} \times 2 $$

UF

DEFINITION: **Unsupportability Factor (UF)** is the result of the division of the *CCD* for an unsupportable system by the *CCD* for a corresponding supportable system, i.e. the system that conforms to supportable architectural framework, such as PCMEF.

- *Consider the PCMEF design with five classes and that the CCD for it is also 5.*
- *For a corresponding unsupportable system, the CCD would be 20:*

$$ {}_5CCD_2 = \frac{5!}{2!(5-2)!} \times 2 = \frac{120}{12} \times 2 = 20 $$

  - *The UF is therefore 20/5 = 4.*
  - *The UF factor serves as a modifier of the more detailed metrics computed for designs/systems that were found to be unsupportable.*

CMD

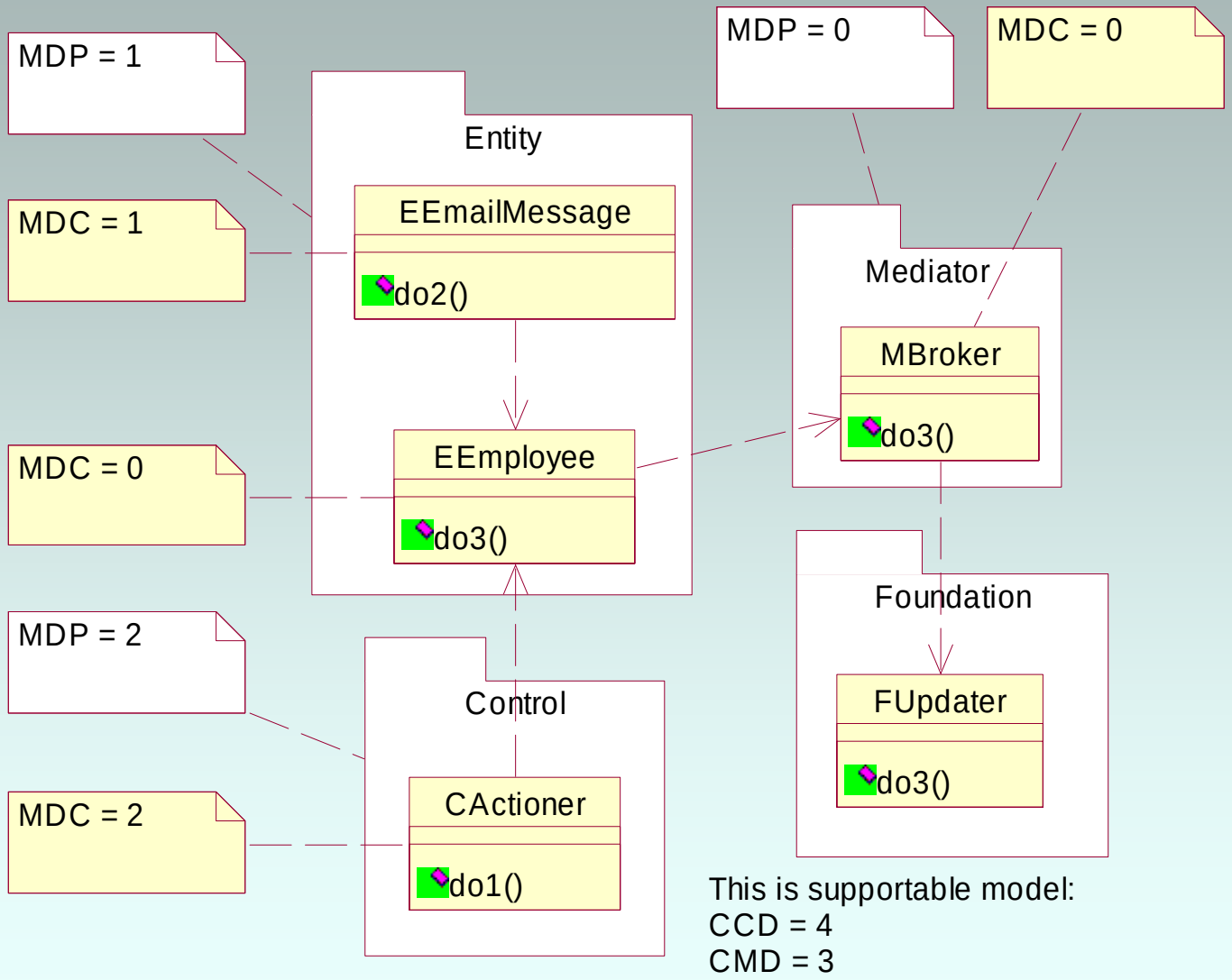
DEFINITION: **Cumulative Message Dependency (CMD)** is the total supportability cost over all Synchronous Messages SM_i within *client objects* of the costs associated with changes to methods M_j in *supplier objects* or *responsible delegator objects* that are accountable for servicing SM_i. When calculating *CMD*, the dependency value for offending (unsupportable) messages is increased by the *Unsupportability Factor* (*UF*).

- *If a responsible delegator object delegates the work to an object in another package then the cost of inter-package dependency is carried by the responsible delegator.*
- *Further delegation sequence does not result in an additional cost (i.e. non-responsible delegators do not carry a maintainability cost).*

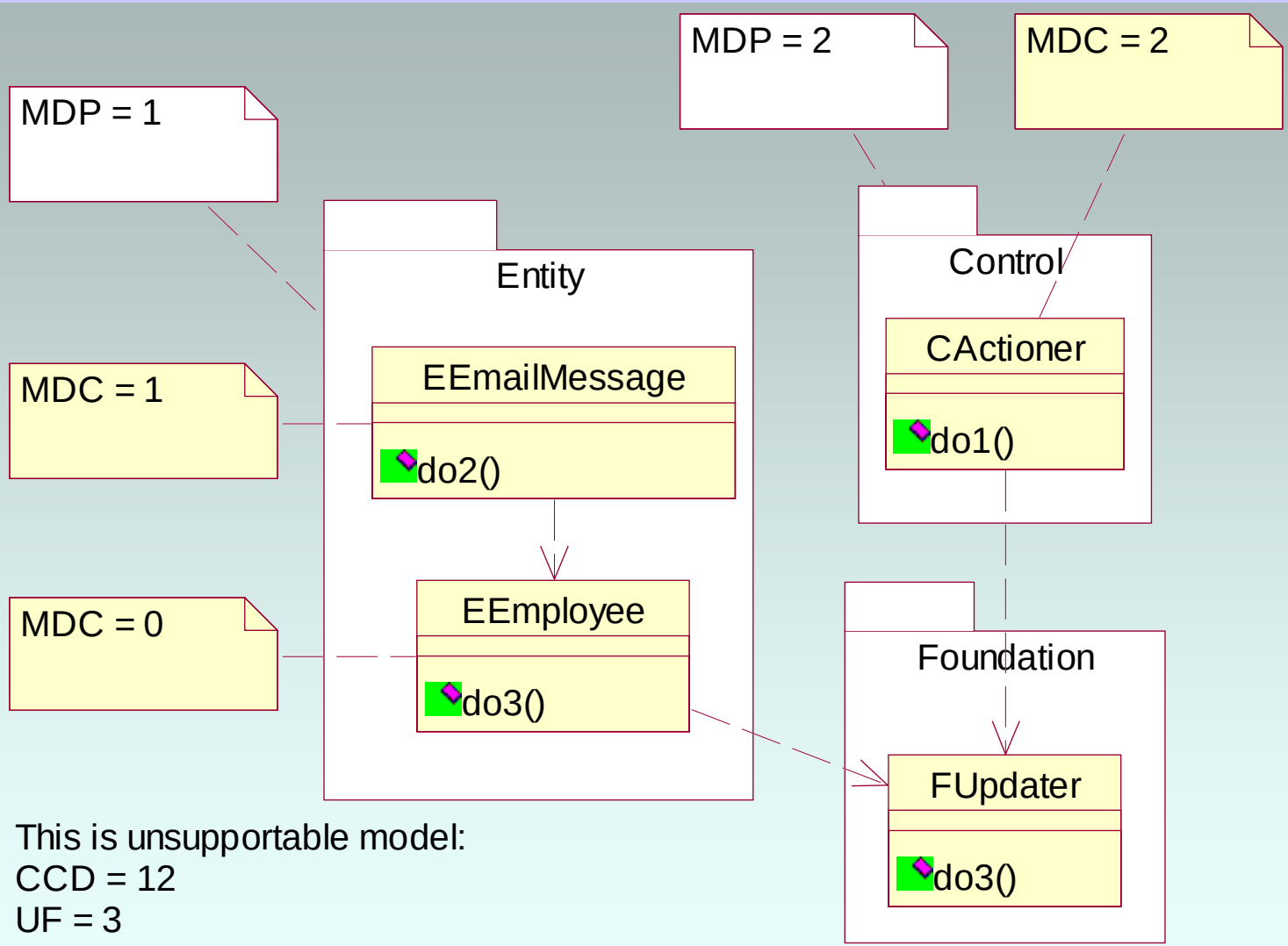
CMD – calculation example

- *Consider a class C that contains two methods m1 and m2.*
- *Consider further that m1 calls m2 (as the only thing that it does).*
- *If m2 is an empty method, then MDC for class C is equal 1 (because m1 depends on m2).*
- *If, however, m2 contained calls (messages) to two other methods m3 and m4 in supplier objects within the same package, then MDC for class C would be equal 3 (because m1 depends on m2, and m2 depends on m3 and m4).*
- *If supplier objects in a neighborhood package serviced m3 and m4, then MDC for class C would be 5.*
- *If supplier objects in a non-neighborhood package (according to the PCMEF framework) serviced m3 and m4, then MDC for class C would further increase by the UF value.*

CMD - supportable



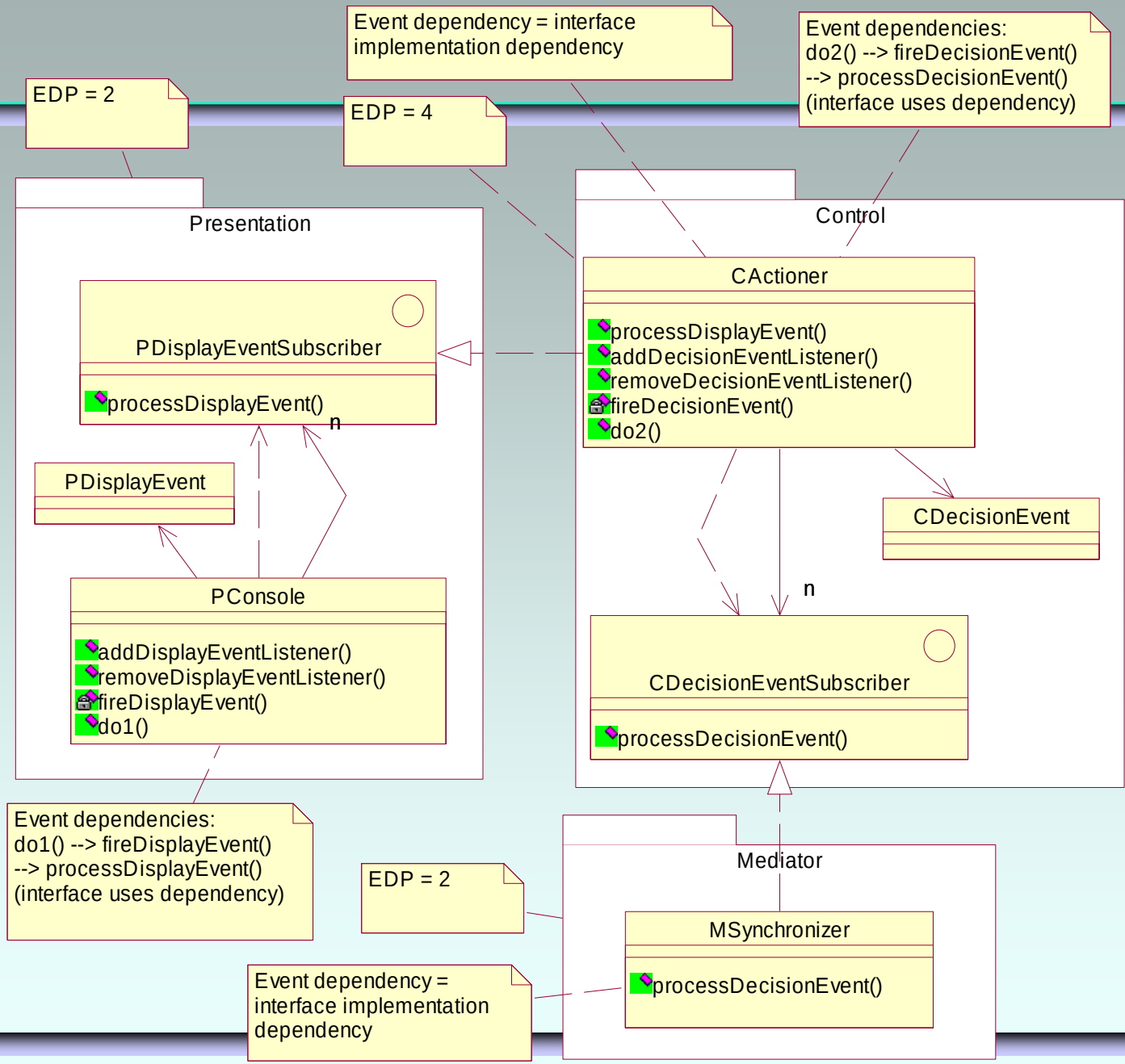
CMD - unsupportable



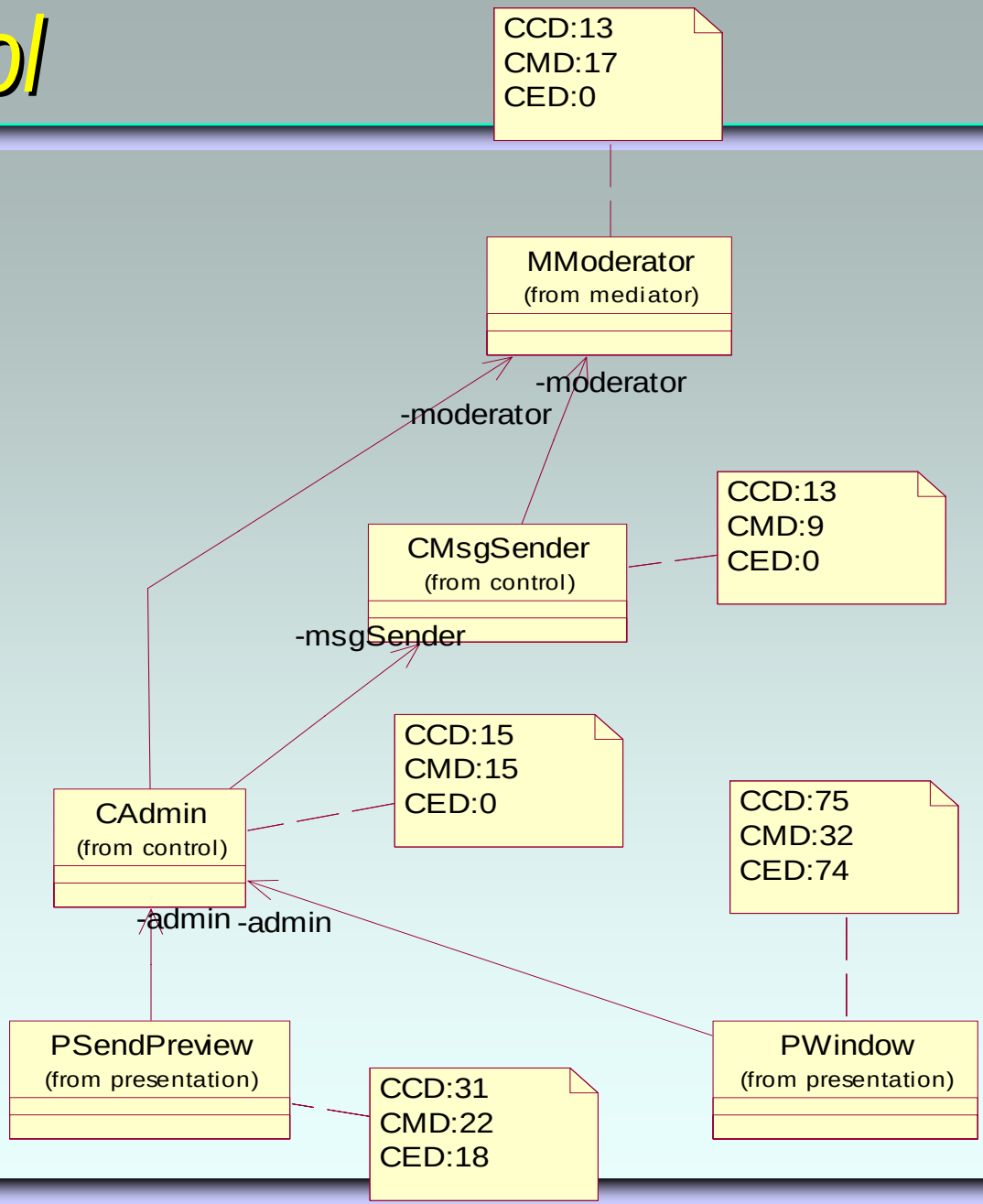
This is unsupportable model:
CCD = 12
UF = 3
CMD = 1+(2*3) = 7

CED

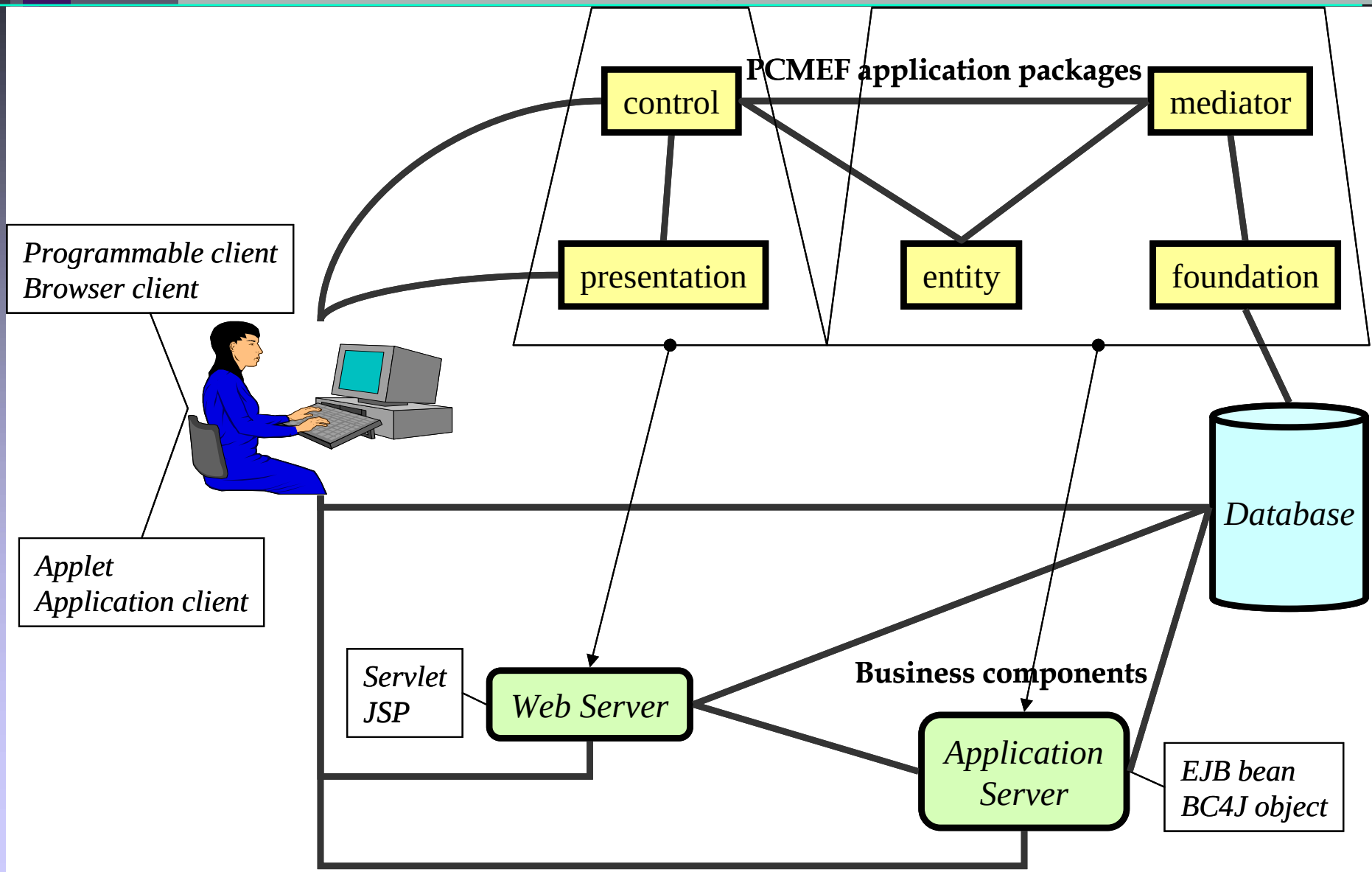
DEFINITION: **Cumulative Event Dependency (CED)** is the total supportability cost over all methods containing "fire event" messages FE_i plus over all methods containing "process event" messages PE_i within *publisher objects* plus over all methods servicing these "process events" SE_i within *subscriber objects*. The PE_i supportability cost is associated with changes to signatures of SE_i methods. The SE_i supportability cost is associated with changes to messages in the bodies of PE_i methods. Messages within *registrator objects* as well messages contained in bodies of SE_i methods are excluded as they are computed as part of the *CMD* calculation. When calculating *CED*, the dependency value for offending (unsupportable) events is increased by the *Unsupportability Factor* (*UF*).


Event dependency = interface implementation dependency
Event dependencies: do2() --> fireDecisionEvent() --> processDecisionEvent() (interface uses dependency)
EDP = 2
EDP = 4
Presentation
Control
CActioner
processDisplayEvent()
addDecisionEventListener()
removeDecisionEventListener()
fireDecisionEvent()
do2()
PDisplayEventSubscriber
processDisplayEvent()
n
PDisplayEvent
CDecisionEvent
PConsole
addDisplayEventListener()
removeDisplayEventListener()
fireDisplayEvent()
do1()
n
CDecisionEventSubscriber
processDecisionEvent()
Event dependencies: do1() --> fireDisplayEvent() --> processDisplayEvent() (interface uses dependency)
EDP = 2
Mediator
MSynchronizer
processDecisionEvent()
Event dependency = interface implementation dependency

DQ tool


CCD:13
CMD:17
CED:0
MModerator
(from mediator)
-moderator
-moderator
CMsgSender
(from control)
CCD:13
CMD:9
CED:0
-msgSender
CAdmin
(from control)
CCD:15
CMD:15
CED:0
CCD:75
CMD:32
CED:74
-admin
-admin
PSendPreview
(from presentation)
CCD:31
CMD:22
CED:18
PWindow
(from presentation)

Pictorial summary



Conclusion – let's return to the nature

- *For every complex problem there is a simple solution – that won't work [H.L. Mencken]*

Counter-conclusion

- *“Whether we understand the world because it is hierarchic or it appears hierarchic because those aspects of it which are not, elude our understanding and observation” (Herb Simon,1962)*
- *According to David Parnas, hirerachical structure is undefined unless we specify precisely what relationship exists between hierarchy layers*
  - *x contains y*
  - *x uses y*
  - *x has access to y*
  - *x gives work to y*
  - *x gives resources to y*
  - *x uses resources of y*

Additional references

- *FOWLER, M. (1999): Refactoring. Improving the Design of Existing Code, Addison-Wesley, 431p.*
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