



51. Über die Herstellung großer Softwaresysteme

Prof. Dr. rer. nat. habil. Uwe Aßmann
Institut für Software- und
Multimediatechnik
Lehrstuhl Softwaretechnologie
Fakultät für Informatik
TU Dresden
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- 1) Software-Produkte
- 2) Große Systeme
- 3) Was heißt "Software Engineering"?
- 4) Geschichte
- 5) Ihre Zukunft

- ▶ Zuser Kap. 1-3 *oder*
- ▶ Ghezzi Chapter 1 *oder*
- ▶ Pfleeger Chapter 1; Chap 8.1

- ▶ <http://homepages.cs.ncl.ac.uk/brian.randell/NATO/> The first International Conference on Software Engineering (ICSE) 1968.
- ▶ S. Garfunkel Die schönsten Software-Fehler
<http://www.wired.com/news/technology/bugs/0,2924,69355,00.html>
- ▶ Peter G. Neumann <http://www.risks.org> Das Risk Digest sammelt voller Akribie Softwarefehler
- ▶ IEEE ACM code of ethics for Software Engineers
<http://www.computer.org/cms/Computer.org/Publications/code-of-ethics.pdf>



- ▶ JDK Tutorial für J2SE oder J2EE, www.java.sun.com
- ▶ Dokumentation der Jgrapht library <http://www.jgrapht.org/>
 - Javadoc <http://www.jgrapht.org/javadoc>
 - <http://sourceforge.net/apps/mediawiki/jgrapht/index.php?title=jgrapht:Docs>
- ▶ Dokumentation der Library für verteilte Graphen GELLY (Teil von Apache Flink)
 - http://ci.apache.org/projects/flink/flink-docs-master/gelly_guide.html

Für Hängebrücken
gibt es keine
Bastler-Bausätze.

Michael Jackson, IEEE Software 1/1998



Englischer Originaltext des Zitats: "There is no do-it-yourself-kit for suspension bridges."

Softwaretechnologie behandelt nicht (oder nur am Rande) Themen der Programmierung, sondern die speziellen Fragestellungen bei der Konstruktion großer Softwaresysteme, die nur

51.1. Herstellung Großer Softwaresysteme

Softwaresystem: Ein System (oder Teilsystem), dessen Komponenten aus Software bestehen

Klassifikation von Software:

- Generisches Produkt oder Einzelanfertigung (vereinbartes Produkt)?
- Systemsoftware oder Anwendungssoftware?
- eingebettete (produktintegriert) oder eigenständig?
- Realzeitanforderungen oder flexiblere Zeitanforderungen?

51.1. Software-Produkte

How to Earn Money with Products

Ensure that programs run only finitely many times



DRESDEN
concept
Excellence aus
Wissenschaft
und Kultur

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How to Ensure that Programs Run Finitely Many Times

7

Softwaretechnologie (ST)

- ▶ Run as applet
- ▶ run as a webservice
- ▶ Cloud-based registration of run
- ▶ Checking a local memory file in the library data
- ▶ Timed licence:
 - Read by reflection the day of installation
 - After the deadline, show advertisement
- ▶ Buy uses (pay-per-use)



Was heißt hier "groß"?

- ▶ Klassifikation nach W. Hesse:

Klasse	Anzahl Code-Zeilen	Personenjahre zur Entwicklung
sehr klein	bis 1.000	bis 0,2
klein	1.000 - 10.000	0,2 - 2
mittel	10.000 - 100.000	2 - 20
groß	100.000 - 1 Mio.	20 - 200
sehr groß	über 1 Mio.	über 200

Quelle: Gumm/Sommer,
Einführung in die
Informatik, 4. Auflage, 2000,
S. 639

Annahme: eine Person
produziert pro Tag ca. 10 bis
100 Zeilen Programmcode,
d.h. ca. 5000 Zeilen im Jahr.

Riesige Systeme

- ▶ Telefonvermittlungssoftware EWSD (Version 8.1):
 - 12,5 Mio. Code-Zeilen
 - ca. 6000 Personenjahre
- ▶ ERP-Software SAP R/3 (Version 4.0)
 - ca. 50 Mio. Code-Zeilen
- ▶ Gesamtumfang der verwendeten Software (Anfang 2000):
 - Credit Suisse 25 Mio. Code-Zeilen
 - Chase Manhattan Bank: 200 Mio. Code-Zeilen
 - Citicorp Bank: 400 Mio. Code-Zeilen
 - AT&T: 500 Mio. Code-Zeilen
 - General Motors: 2 Mrd. Code-Zeilen

Abkürzungen:

EWSD = Elektronisches Wählsystem Digital (Siemens-Produkt)
ERP = Enterprise Resource Planning
SAP: Deutscher Software-Konzern

Quellen für die Zahlen:

EWSD: Siemens-interne
Information

SAP: www.ct-software.com

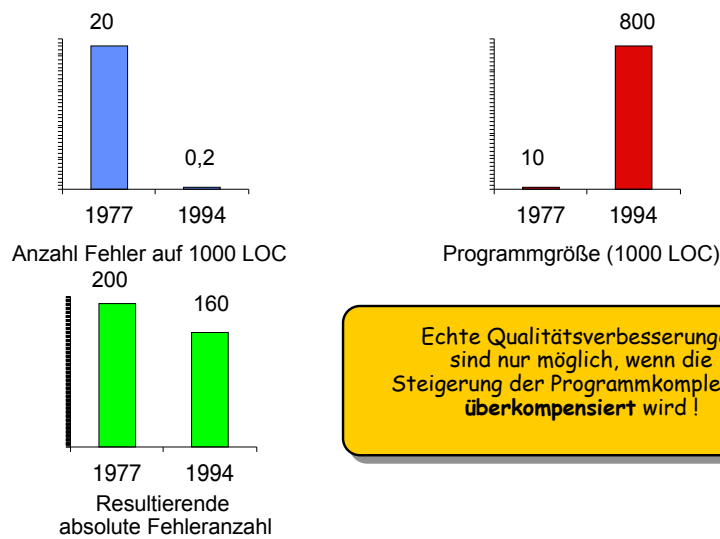
Jahr 2000: Gary North's
Y2K Links and Forums,
basierend auf

Presseberichten zwischen
1996 und 1999

Quellcode von Windows
2000 (gerüchteweise): ca.

Komplexitätswachstum und Fehlerrate

10 Softwaretechnologie (ST)



Wachsende Komplexität

Größe:

häufig über 100.000
lines of code (LOC),
bis hin zu mehreren
Millionen LOC
(z.B. SAP R/3, Siemens
EWSD im 10
Millionen-Bereich.
Windows 95: 30 Mio.
LOC)

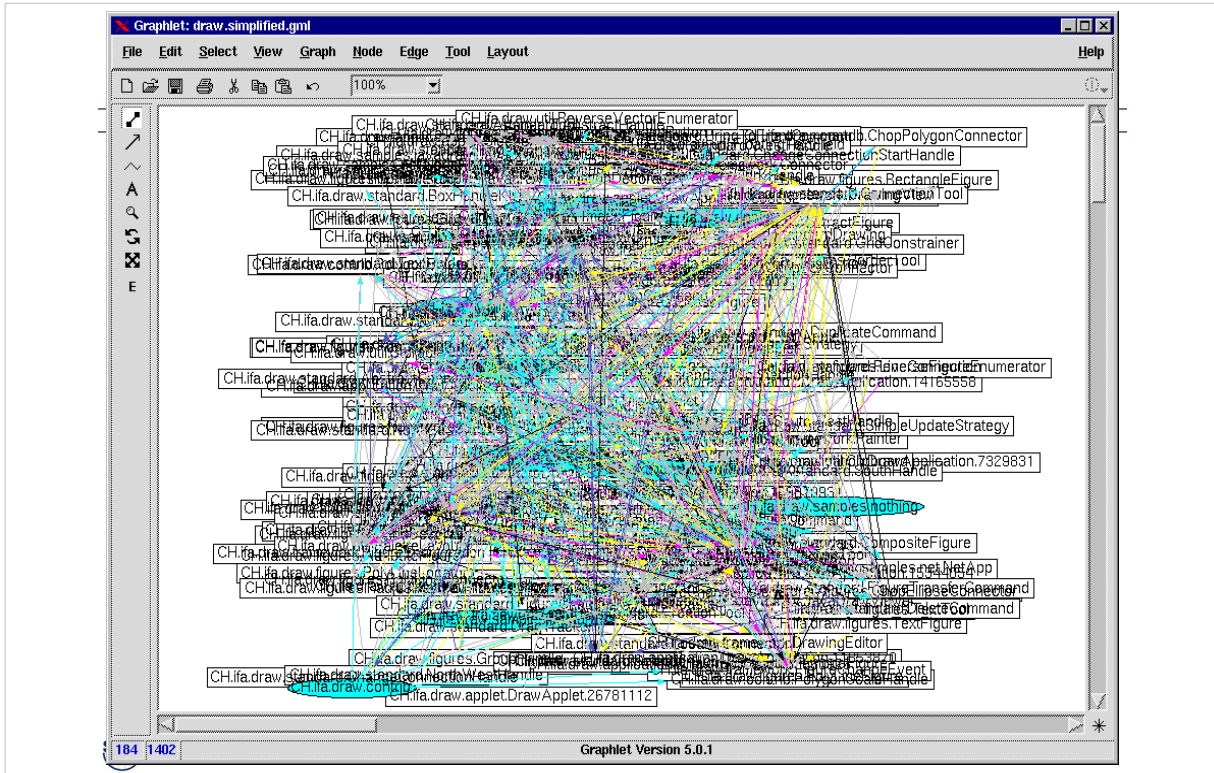
Arbeitsaufwend:

Human Problems

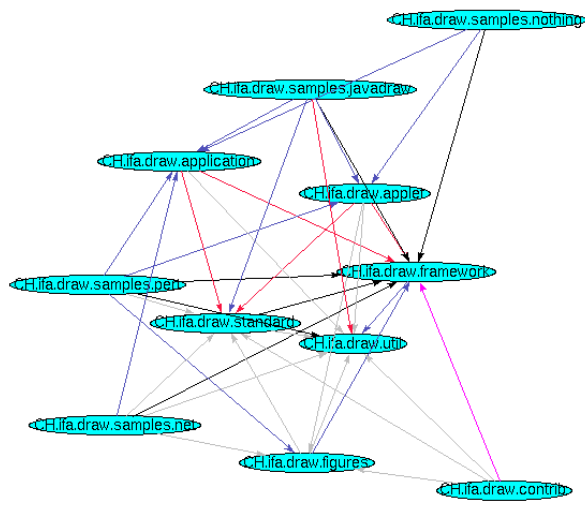
- ▶ Programmers are not educated well
 - To develop
 - To communicate
- ▶ Software construction is a social process
 - It's hard to organize people
- ▶ Software stays, the people go
 - Software evolves, many versions
- ▶ Projects run out of time
 - How to control?

Structural Problems

- ▶ The following figures are taken from the Goose Reengineering Tool, analysing a Java class system [Goose, FZI Karlsruhe, <http://www.fzi.de>]



Totally Collapsed



Permanente Softwarekrise ?

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- ▶ "Software-Krise":
 - Fehler in Computersystemen sind fast immer Softwarefehler.
 - Software wird nicht termingerecht und/oder zu höheren Kosten als geschätzt fertiggestellt.
 - Software entspricht oft nicht den Anforderungen ihrer Benutzer.
- ▶ Begriff der Software-Krise existiert seit 1968 bis heute !
 - 70er Jahre:
 - Mangelhafte Beherrschung der Basistechnologie
 - 90er Jahre und Millennium:
 - Grosse (software-)technologische Fortschritte
 - Mangelhafte Beherrschung des Wachstumstempos und des Anpassungsdrucks

We undoubtedly produce software by backward techniques.
D. McIlroy, ICSE 1968

1972: „Die Computerindustrie hat kein einziges Problem gelöst, sondern nur neue geschaffen. Sie hat das Problem geschaffen, ihre Produkte zu benutzen.“ (E. Dijkstra)

Quelle Dijkstra: The humble programmer. CACM Vol. 15, No. 10, 1972.

Quelle Government

The Industry

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- ▶ Top Players: IBM, Microsoft, Google, HP, Hitachi, Computer Associates, Oracle, Fujitsu, SAP, Bull HN, Novell
- ▶ About 10% of the national turnaround of the US
 - 5% of employees, about the size of car industry
- ▶ PC-game equates Hollywood film (\$50 mill. in first week)
- ▶ 2/3 standard software : 1/3 individual software (with growing rate)
- ▶ Im 'Quartal erwirtschaftet Microsoft
 - Umsatz im Bereich von 10-15 Milliarden US-Dollar.
 - operativer Gewinn: 3-6 Milliarden US-Dollar bewegen.
- ▶ Atlassian-Ecosystem grows 50% every year! www.atlassian.com

Balyert einfügen S. 28

Life Time of Software

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- ▶ Average: 5 – 15y
 - max > 35 y (control software, certified systems, data bases)
 - Development time: 1 - 3y
- ▶ Microsoft (1994):
 - 50% turnaround from products of the last 12 months
 - 50 Products/y
 - new version every 18-24 months
 - 2/3 of a new version are new

Costs

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- ▶ Contrary to Grosch's Law,
 - Hardware speed doubles every 2 years
- ▶ Software productivity increases only about $< 5\%/y$.
- ▶ Costs
 - acad. Prototype / acad. Product / Product = 1 : 3 : 3
 - Commercialization is rather difficult
- ▶ Relation of development and maintenance 40:60 up to 20:80
 - Development and maintenance are done by different departments

Costs: Extreme Requirements

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- ▶ Telecommunication: Failure < 1 h./40 y., working rate 99.999%
 - One second failure may cost \$5Mio
- ▶ Certification
 - Insurance: certified software must be executable after 40 years
 - German pension rules of the 50s must be processed today
 - Nobody knows the details anymore!
 - Solution: write an interpreter for the old assembler
 - This has happened twice..

Cost Example: The Year 2000 Problem

- ▶ COBOL programmers saved space and stored only the last two digits of the year
 - In the 70s, programs should only live 20 years
- ▶ In 2000, catastrophes were prophesied
 - Power plants?
 - Pension insurances (birth dates)
- ▶ From 1996 on, the industry panicked
 - Spent enormous amounts to update software
- ▶ New systems got installed
 - SAP R/3 with date data type
- ▶ Rewriting didn't work
 - Programmers didn't trust the rewrites
 - Solution: sliding window technique



Cost Example: The Euro Introduction in 2001

- ▶ End of 2001, many countries introduced the Euro
- ▶ Too bad: on paper, the Euro was introduced 2 years before
 - Some companies had to maintain double booking for 2 years
 - At least for some months in 2002
 - Double booking was very costly: accounts had to be printed in two currencies
- ▶ How to test the transition?
 - In May 2001, the Dresdner bank ran a test
 - Which failed,... And produced many wrong money transfers!
- ▶ Many people worked day and night...
 - One of my friends was responsible for the ATM machines...

Cost Example: Telecommunication

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- ▶ Telecommunication software product line
 - 20-30 000 Module of 1000 loc (lines of code)
- ▶ Single product has 2-8000 modules
- ▶ Necessary: 5000 persons/7years.
- ▶ Costs ca. 7 billion €.
- ▶ Size of world market 50 billion €
- ▶ How many suppliers can exist?

Programmer Productivity – Rules of Thumb

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- ▶ System software: 1000-2000 loc/y
- ▶ System like Software: 5000 loc/y
- ▶ Application software: 5-10000 loc/y
- ▶ Master's thesis: 10-20000 loc/thesis
- ▶ Individual differences up to factor 5
 - Has not changed in the last 30 years
- ▶ Differences by programming language and reuse mechanisms



51.2 "Software-Engineering"

Softwaretechnologie \leq Software-Engineering = Softwareingenieurswesen
Softwaretechnik: Unterbegriff von Softwaretechnologie

software engineering: Die Entdeckung und Anwendung solider
Ingenieur-Prinzipien mit dem Ziel, auf wirtschaftliche Weise Software zu
bekommen, die zuverlässig ist und auf realen Rechnern läuft.

(F.L. Bauer, NATO-Konferenz Software-Engineering 1968)

What is Software Engineering?

- ▶ It teaches the production of software with engineering techniques (the engineer's toolkit)
 - Analysis
 - Construction (development, invention)
 - Validation
 - Improvement
- ▶ in a structured software development process

Engineers measure, build, validate, and improve

- ▶ Analyze (measure)
 - Measuring
 - Searching and finding
 - Controlling
 - Describe the world with *descriptive* models
- ▶ Construct (design, development, invent, build)
 - Modelling: prescribe the form of a system with a *prescriptive* model
 - Describing the infinite and the unknown with finite descriptions
 - Structuring (making the model more clear)
 - Refinement (making the model more precise and detailed)
 - Elaboration (adding more details)
 - DomainTransformation (changing representation of model)

- ▶ Form hypotheses and validate them
 - Experimentation (empirical software engineering)
 - Checking (consistency, completeness, soundness)
 - Testing
 - Proving (formal software engineering)
 - Statistics
- ▶ Improve
 - Reverse engineer
 - Optimize with regard to a value model

- ▶ Probleme identifizieren (beobachten)
 - ▶ Theorie und Verbesserungshypothesen entwickeln
 - ▶ Lösungen entwickeln (Techniken, Methoden u. Werkzeuge)
 - ▶ Empirisches Testen (danach Iteration)
-
- ▶ Merke: Fehlt eine Aktivität, liegt kein ingenieurmässiges Arbeiten vor!

Was ist eine Software-Entwicklungsmethode?

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- ▶ Beschrieben in Lehrbüchern und Handbüchern
- ▶ Zweck: Hilfe bei der Erstellung von Software
 - Bessere Planbarkeit der Entwicklung
 - Bessere Struktur des Produkts



Darstellungsformen
• Syntax für Dokumente
• Diagrammtypen

Werkzeug-
unterstützung

Verfahren
• Analyse
• Transformation

Entwicklungs-
Methode

Vorgehensmodell
• Schritte
• Reihenfolge
• Ergebnisse



Software- Entwicklungsmethode

(engl. *method*,
methodology)

gibt menschlichen
Entwicklern einen
Rahmen zur Entwicklung
von Softwareprodukten
vor.

Eine Software- Entwicklungsmethode

Another Important Aspect of Software Engineering

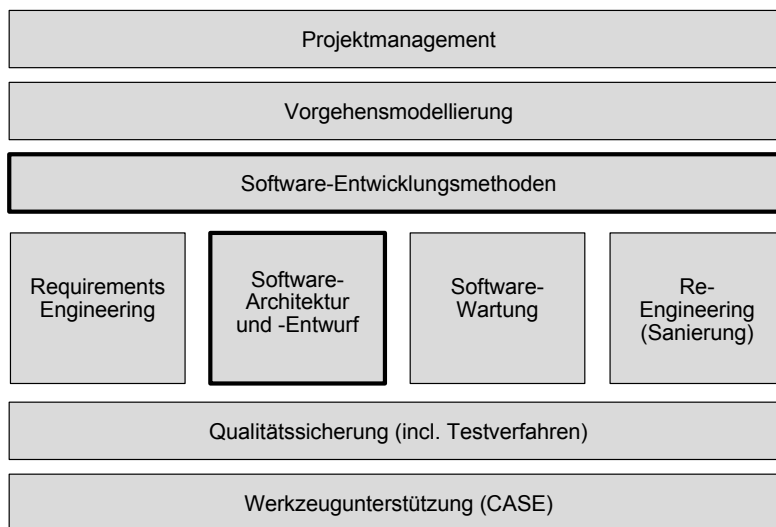
- ▶ It teaches the production of software with *languages* for
 - Analysis
 - Design
 - Validating and experimenting
 - Improvement
- ▶ On different abstraction levels
 - Imprecise (sketching information)
 - Precise (such that code can be generated from the specifications)
- ▶ In different syntaxes
 - Informal, formal, diagrammatic, high-level
- ▶ Both on the technical and on the process (management) level



Definitions

- ▶ **Program:** Sources, object files, libraries (also called *bananaware*)
- ▶ **Testable system/program:** Reliable Program with extensive test suite
- ▶ **Software:** Testable program with user and developer documentation, requirement specification, design descriptions, implementation description
- ▶ **Product:** Mature software. Good, simple, and pedagogic documentation. Simple Installation. Support guaranteed
 - Scalable for many users and scenarios
 - Reliable
 - Note: Companies like products
- ▶ **Product line (product family):** A group of products, having a common framework and product-specific extensions.
 - Note: every product is sold independently

- ▶ Specification programs (S-programs)
 - A formal problem specification exists, describing problem and solution
 - The specification allows for checking the solution on validity (formal checks or formal proofs)
- ▶ Problem solving programs (P-programs)
 - Can be formalized and checked
 - Have requirements for usability and appropriate
- ▶ Embedded programs (E-programs)
 - Embedded in a social context
 - The specification is a social process; the functionality depends on the involved people
 - No correctness proofs possible



Diese Vorlesung befaßt sich nur mit Teilen des komplexen Themengebiets (fett umrandet).
Im Fachgebiet Softwaretechnik im Hauptstudium werden verschiedene weiterführende Vorlesungen angeboten,



51.3 Geschichte

A Little History

- ▶ NATO Conference on Software Engineering in Garmisch-Patenkirchen. Oct 7-10, 1968
- ▶ *"The whole trouble comes from the fact that there is so much tinkering with software. It is not made in a clean fabrication process. What we need is Software Engineering."* Friedrich L. Bauer, 1968
- ▶ Hence the conference was called "on Software Engineering"
- ▶ [in Thayer&McGettrick IEEE Press]
- ▶ "Software Crisis"
- ▶ "Component Software"



Photos of Famous People [Courtesy Brian Randell's Web Site]



E. Dijkstra



K. Samuelson
(Stack)



D. McIlroy
"Mass-produced
Software Components"



W. van der Poel



B. Randell



D. Gries



T. Hoare



3rd from right: G. Goos

Photos of Famous People [Courtesy Brian Randell's Web Site]



A. Perlis



J. Feldman



C. Strachey



N. Wirth



P. Brinch Hansen





51.4 Karriere

- ▶ First, you will be a designer and programmer in a team
 - You will need design skills most urgently for your own and small-size projects
 - In the software process, design flaws are most costly
- ▶ Afterwards, you will be project leader
 - Without good knowledge in design, you will not be a good developer nor project leader
- ▶ And then manager
 - But neither a good manager
 - Basic Microsoft strategy: every manager must be able to program

- ▶ .. but some gamble instead [Bill Gates, The Way Ahead]..

- ▶ Some become entrepreneurs
- ▶ What is an entrepreneur?
 - [Prof. R. Würth: Lecture notes on entrepreneurship
http://www.iep.uni-karlsruhe.de/seite_260.php]

Ein Unternehmer ist ein Problemlöser.
Insbesondere sind ein Unternehmer und ein Kapitalist
zweierlei. Der Kapitalist sieht den Gewinn im Mittelpunkt,
aber der Unternehmer findet seine Befriedigung nur im
Lösen von Problemen seiner Kunden und seiner
Mitarbeiter. Damit kann er zwar auch Geld verdienen, im
Wesentlichen lebt er aber nur einen grundlegenden Zug
des Menschen aus: für Probleme befriedigende Lösungen
zu finden.

Your Career (III) - Consultant

- ▶ A consultant teaches and employs modern technology at a customer site
 - Must lead in knowledge and technology
 - Individual software
- ▶ Outsourcing
 - to Asia or MOE (Mittelosteuroopa) is a trend
 - how to manage distributed projects?

Was haben wir gelernt?

- ▶ Der Ingenieur misst, entwirft, validiert und verbessert
- ▶ Keiner Ingenieur bleibt Programmierer, sondern muß sich entwickeln



- ▶ Die deutschen Folien der Softwaretechnologie-Vorlesung stammen zu grossen Teilen aus den Jahren 2000-2003 und wurden von Prof. Dr. Heinrich Hussmann, jetzt LMU München, erstellt. Used by permission.